US011688226B2

(12) **United States Patent**
Brown et al.

(10) **Patent No.: US 11,688,226 B2**
(45) **Date of Patent: Jun. 27, 2023**

(54) **RENDERING PIPELINE FOR ELECTRONIC GAMES**

(71) Applicant: **Aristocrat Technologies, Inc.**, Las Vegas, NV (US)

(72) Inventors: **Jody Brown**, Austin, TX (US); **Joseph Bibbo**, Austin, TX (US)

(73) Assignee: **Aristocrat Technologies, Inc.**, Las Vegas, NV (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 371 days.

(21) Appl. No.: **17/125,483**

(22) Filed: **Dec. 17, 2020**

(65) **Prior Publication Data**

US 2021/0217270 A1 Jul. 15, 2021

Related U.S. Application Data

(60) Provisional application No. 63/090,661, filed on Oct. 12, 2020, provisional application No. 62/959,407, filed on Jan. 10, 2020.

(51) **Int. Cl.**
G07F 17/32 (2006.01)

(52) **U.S. Cl.**
CPC ***G07F 17/3211*** (2013.01)

(58) **Field of Classification Search**
CPC .. G07F 17/3211; G06F 9/45558; A63F 13/33; A63F 13/358; A63F 13/355; H04L 67/01
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,070,501 B2 7/2006 Cormack
D624,927 S 10/2010 Allen
(Continued)

FOREIGN PATENT DOCUMENTS

AU 2013202658 A1 1/2014
AU 2013251288 A1 5/2014
(Continued)

OTHER PUBLICATIONS

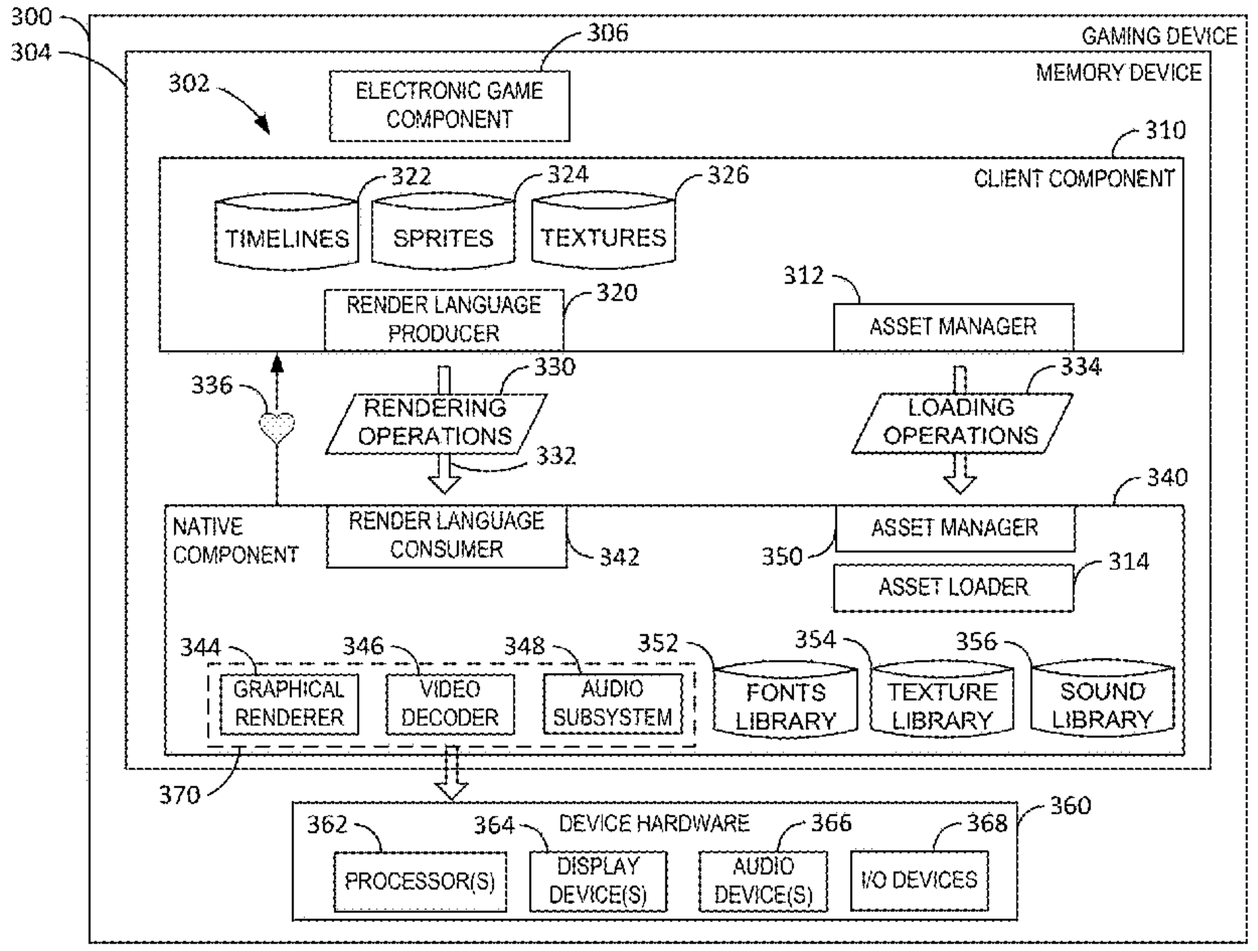
Office Action dated Sep. 2, 2020 for U.S. Appl. No. 16/383,435 (pp. 1-7).
(Continued)

Primary Examiner — William H McCulloch, Jr.
Assistant Examiner — Ankit B Doshi
(74) *Attorney, Agent, or Firm* — Armstrong Teasdale LLP

(57) **ABSTRACT**

An electronic gaming device provides a rendering pipeline for an electronic game. The rendering pipeline includes a client component and a native component of the rendering pipeline, where the client component is configured to: initiate a rendering operations pipe between the client component and the native component; convert display commands from a source language of the electronic game into rendering operations of an intermediate rendering language; and transmit the rendering operations through the rendering operations pipe to the native component. The native component is configured to: receive the rendering operations via the rendering operations pipe; translate the rendering operations from the intermediate rendering language into rendering operations of the native component; and perform the rendering operations of the native component on the display device.

20 Claims, 7 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

D648,347	S	11/2011	Chaudhri	
8,360,851	B2	1/2013	Aoki	
8,911,294	B2	12/2014	Antkowiak	
9,424,720	B2	8/2016	Suda	
9,928,691	B2	3/2018	Olive	
D824,932	S	8/2018	Joensson	
10,074,206	B1 *	9/2018	Ingegneri	G06F 9/45558
D834,596	S	11/2018	Bae	
2003/0216165	A1	11/2003	Singer	
2004/0137982	A1	7/2004	Cuddy	
2006/0189369	A1	8/2006	Taylor	
2007/0060248	A1	3/2007	Rodgers	
2007/0129135	A1	6/2007	Marks	
2009/0054129	A1	2/2009	Yoshimura	
2009/0239634	A1	9/2009	Nguyen	
2010/0075737	A1	3/2010	Bluemel	
2010/0210343	A1	8/2010	Englman	
2010/0234092	A1	9/2010	Gomez	
2010/0281107	A1	11/2010	Fallows	
2011/0157196	A1 *	6/2011	Nave	A63F 13/358 345/522
2012/0178517	A1	7/2012	Montenegro	
2012/0258786	A1 *	10/2012	Sylla	G07F 17/3211 463/20
2013/0331168	A1	12/2013	Street	
2014/0080564	A1	3/2014	Acres	
2014/0274292	A1	9/2014	Suda	
2014/0323198	A1	10/2014	Tuck	
2015/0310699	A1	10/2015	Meyer	
2016/0042597	A1	2/2016	Olive	
2016/0253873	A1	9/2016	Olive	
2017/0032609	A1	2/2017	Inamura	
2017/0111477	A1 *	4/2017	Davis	H04L 67/01
2017/0148274	A1	5/2017	Olive	
2017/0154498	A1	6/2017	Olive	
2018/0001216	A1 *	1/2018	Bruzzo	A63F 13/33
2018/0075708	A1	3/2018	San	
2018/0268655	A1	9/2018	Olive	
2020/0111312	A1	4/2020	Olive	
2020/0312081	A1 *	10/2020	Perrow	G07F 17/3211

FOREIGN PATENT DOCUMENTS

AU	2014202042	A1	5/2014
EP	0984408	A2	3/2000

OTHER PUBLICATIONS

Australian Examination Report for Application No. 2018278882, dated Dec. 9, 2019, 2 pages.
Australian Examination Report for AU2016100230, dated May 11, 2016, 5 pages.
Australian Examination Report for AU2015210489, dated Jun. 14, 2016, 5 pages.
Australian Examination Report for AU2016202727, dated Jul. 4, 2016, 5 pages.
Australian Examination Report for AU2017101629, dated Jan. 16, 2018, 3 pages.
Australian Examination Report for AU2017204560, dated Feb. 1, 2018, 3 pages.
Australian Examination Report for Application No. 2018241080, dated Sep. 24, 2019.
U.S. Appl. No. 16/455,166, filed Jun. 27, 2019, System and Method for Providing a Feature Game.
Australian Examination Report for Application No. 2019200719, dated Apr. 8, 2020, 3 pages.
Australian Examination Report for AU2017101097, dated Dec. 7, 2017. (3 pages).
Office Action dated Jun. 4, 2020 for U.S. Appl. No. 29/622,662 (pp. 1-8).
Office Action dated Jun. 25, 2020 for U.S. Appl. No. 16/537,223 (pp. 1-11).
Notice of Allowance dated Aug. 31, 2020 for U.S. Appl. No. 29/622,662 (pp. 1-7).
Notice of Allowance dated Dec. 1, 2020 for U.S. Appl. No. 16/383,435 (pp. 1-7).
Corrected Notice of Allowabality dated Jan. 26, 2021 for U.S. Appl. No. 16/383,435 (pp. 1-2).

* cited by examiner

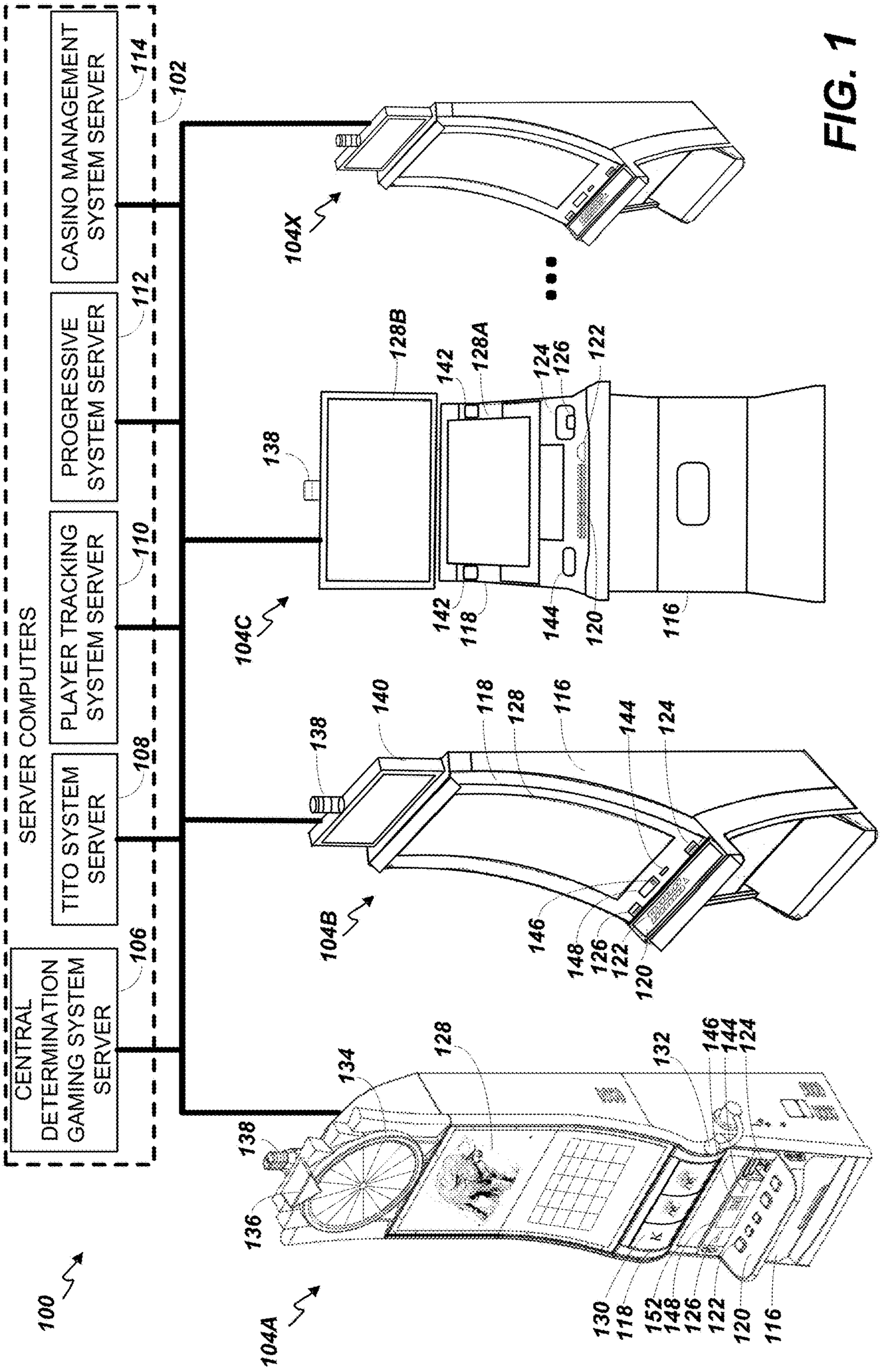

SERVER COMPUTERS
CASINO MANAGEMENT SYSTEM SERVER
114
102
PROGRESSIVE SYSTEM SERVER
112
PLAYER TRACKING SYSTEM SERVER
110
TITO SYSTEM SERVER
108
CENTRAL DETERMINATION GAMING SYSTEM SERVER
106
100
104A
104B
104C
104X
128B
128A
142
124
126
122
138
144
120
116
140
118
128
146
148
132
134
136
130
152

FIG. 1

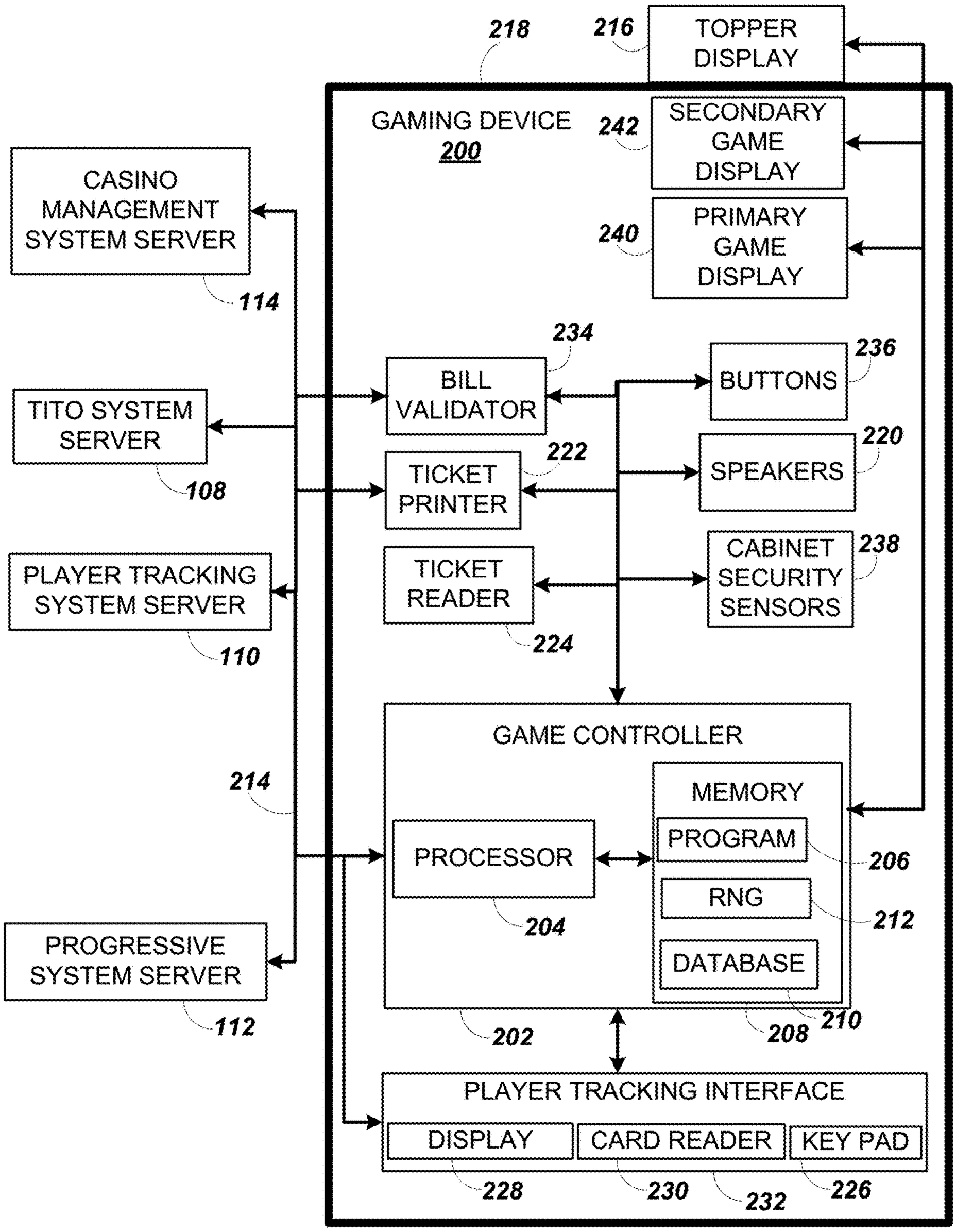

218
216
TOPPER DISPLAY
GAMING DEVICE
200
242
SECONDARY GAME DISPLAY
240
PRIMARY GAME DISPLAY
CASINO MANAGEMENT SYSTEM SERVER
114
234
BILL VALIDATOR
236
BUTTONS
TITO SYSTEM SERVER
108
222
TICKET PRINTER
220
SPEAKERS
PLAYER TRACKING SYSTEM SERVER
110
TICKET READER
224
CABINET SECURITY SENSORS
238
GAME CONTROLLER
214
MEMORY
PROCESSOR
204
PROGRAM
206
RNG
212
DATABASE
PROGRESSIVE SYSTEM SERVER
112
202
208
210
PLAYER TRACKING INTERFACE
DISPLAY
CARD READER
KEY PAD
228
230
232
226

FIG. 2A

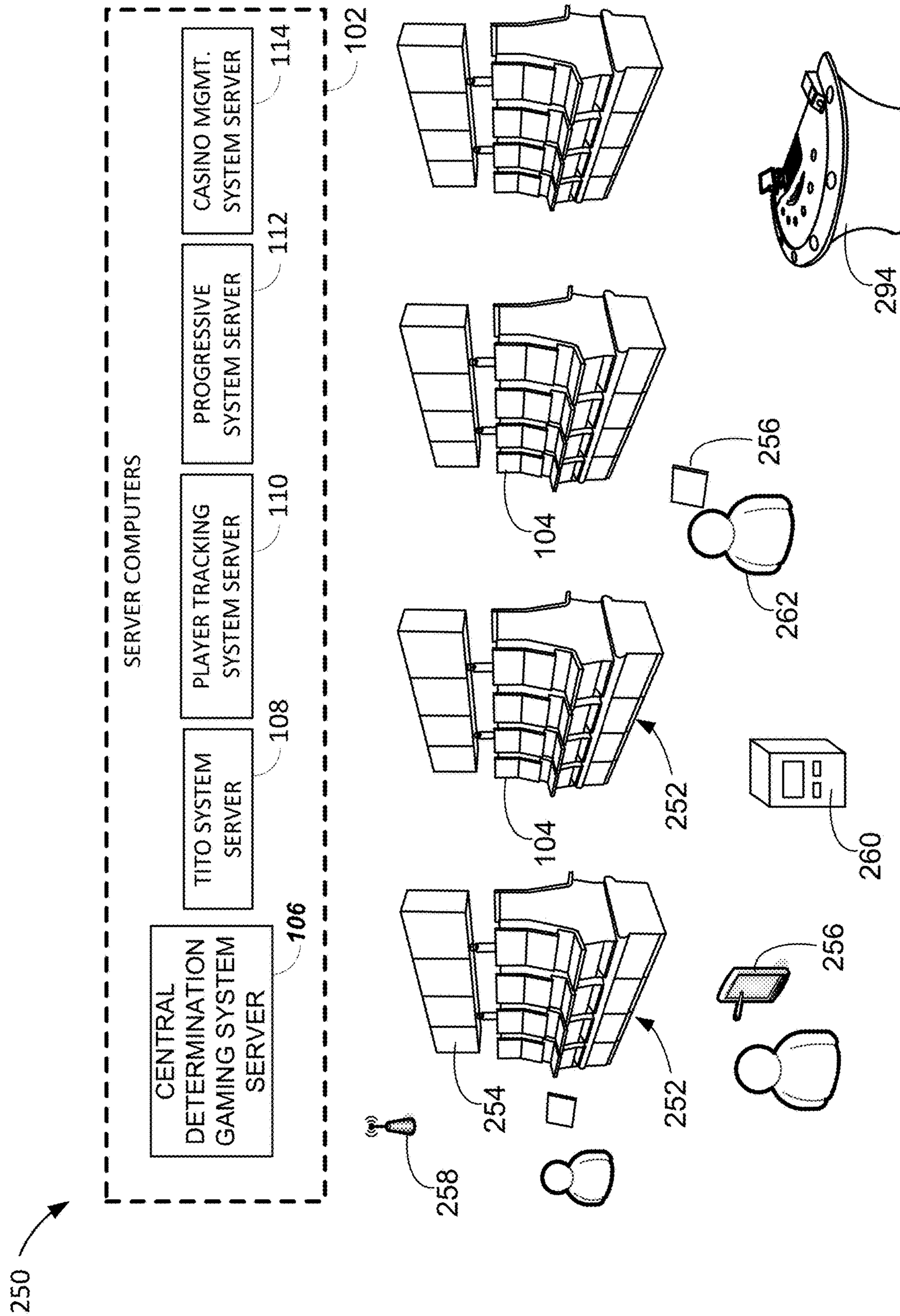
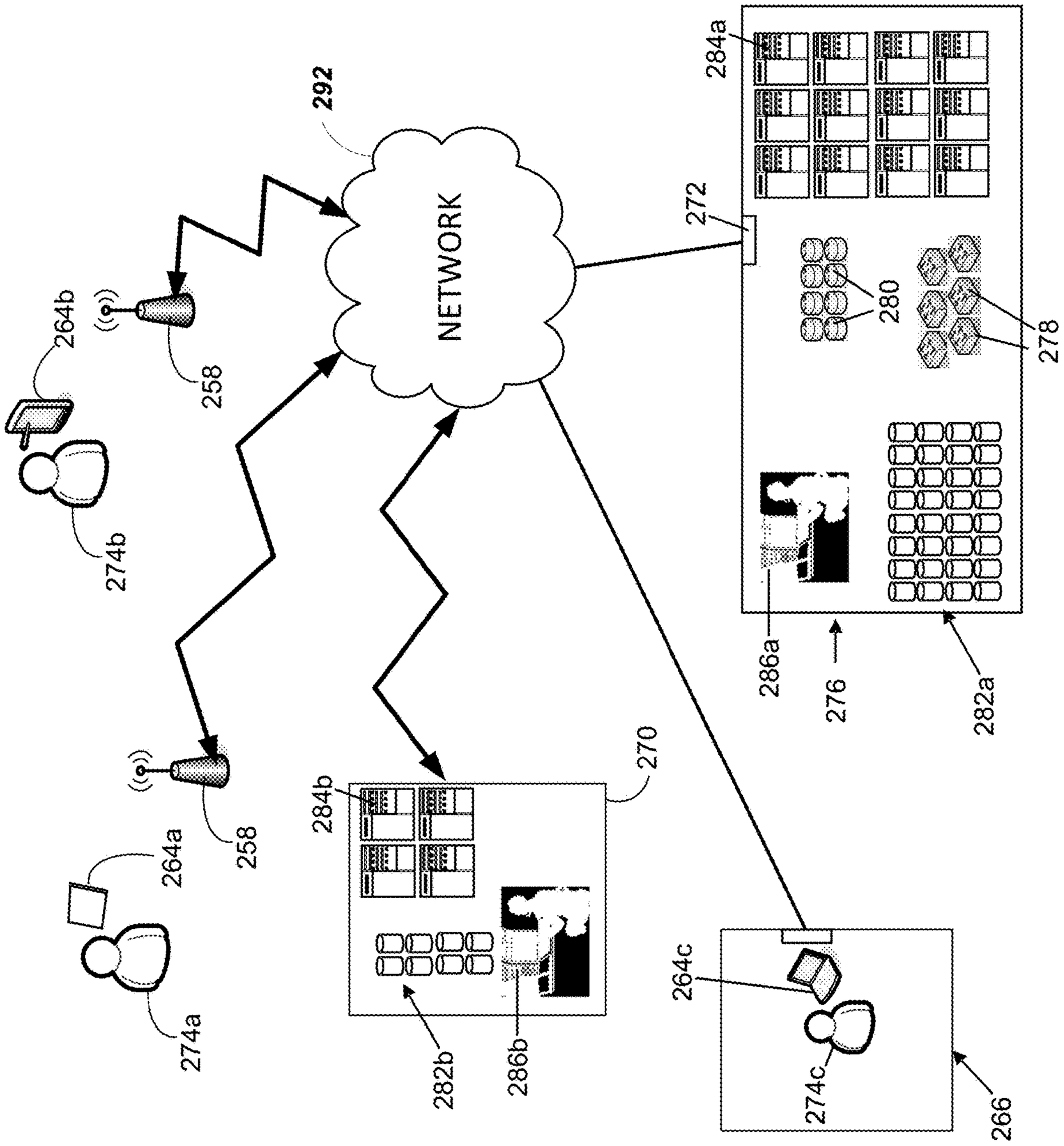

250
SERVER COMPUTERS
CENTRAL DETERMINATION GAMING SYSTEM SERVER
106
TITO SYSTEM SERVER
108
PLAYER TRACKING SYSTEM SERVER
110
PROGRESSIVE SYSTEM SERVER
112
CASINO MGMT. SYSTEM SERVER
114
102
104
252
254
256
258
260
262
294

FIG. 2B

FIG. 2C


292
NETWORK
264b
258
274b
284a
272
280
278
286a
276
282a
264a
258
274a
284b
270
282b
286b
264c
274c
266

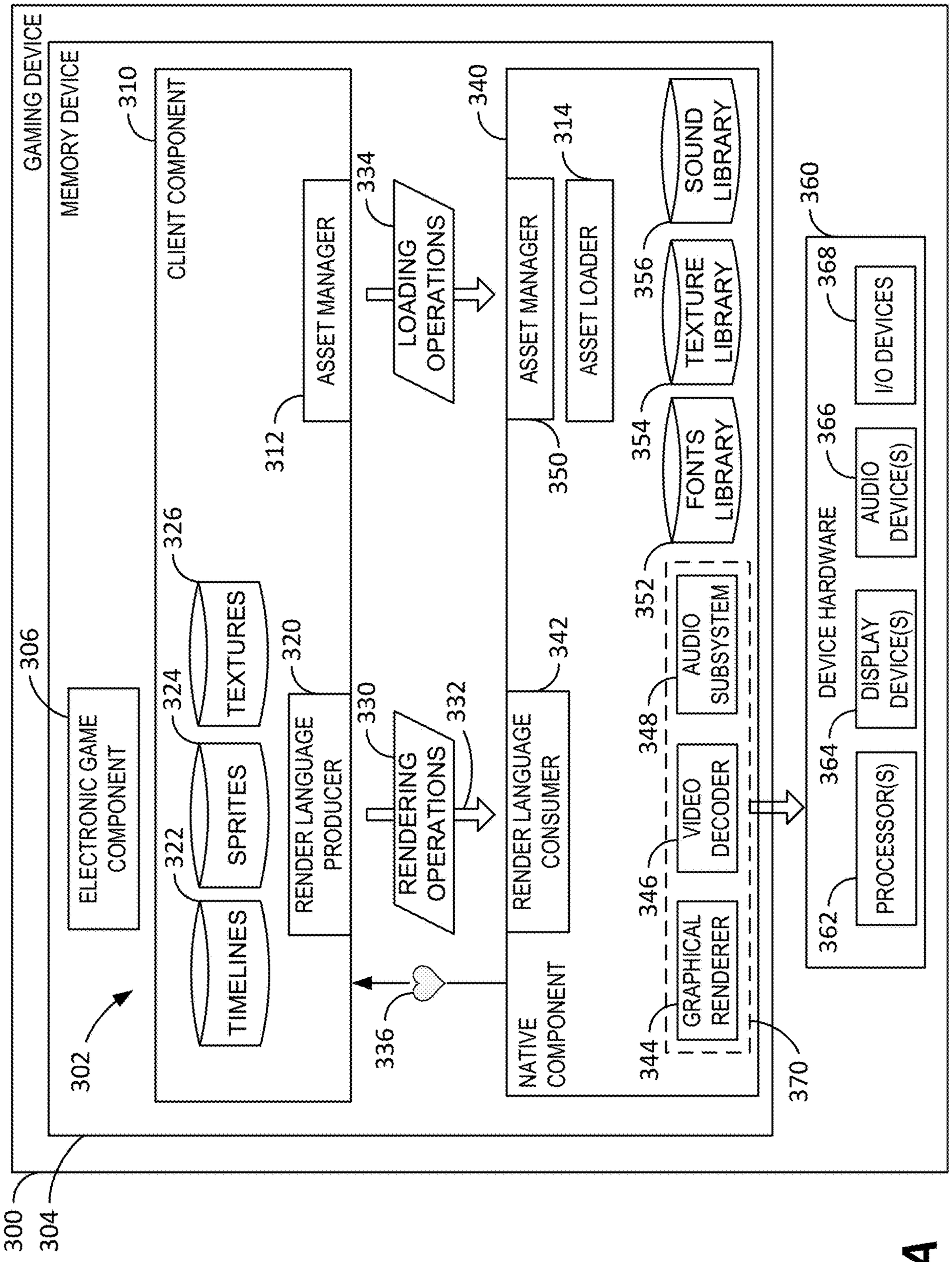

GAMING DEVICE
MEMORY DEVICE
310
CLIENT COMPONENT
ASSET MANAGER
334
LOADING OPERATIONS
340
ASSET MANAGER
314
ASSET LOADER
356
SOUND LIBRARY
TEXTURE LIBRARY
360
368
I/O DEVICES
306
ELECTRONIC GAME COMPONENT
322
324
SPRITES
326
TEXTURES
312
320
RENDER LANGUAGE PRODUCER
330
RENDERING OPERATIONS
332
342
RENDER LANGUAGE CONSUMER
350
354
FONTS LIBRARY
346
VIDEO DECODER
348
AUDIO SUBSYSTEM
352
DEVICE HARDWARE
366
AUDIO DEVICE(S)
362
PROCESSOR(S)
364
DISPLAY DEVICE(S)
TIMELINES
302
336
NATIVE COMPONENT
344
GRAPHICAL RENDERER
370
300
304

FIG. 3A

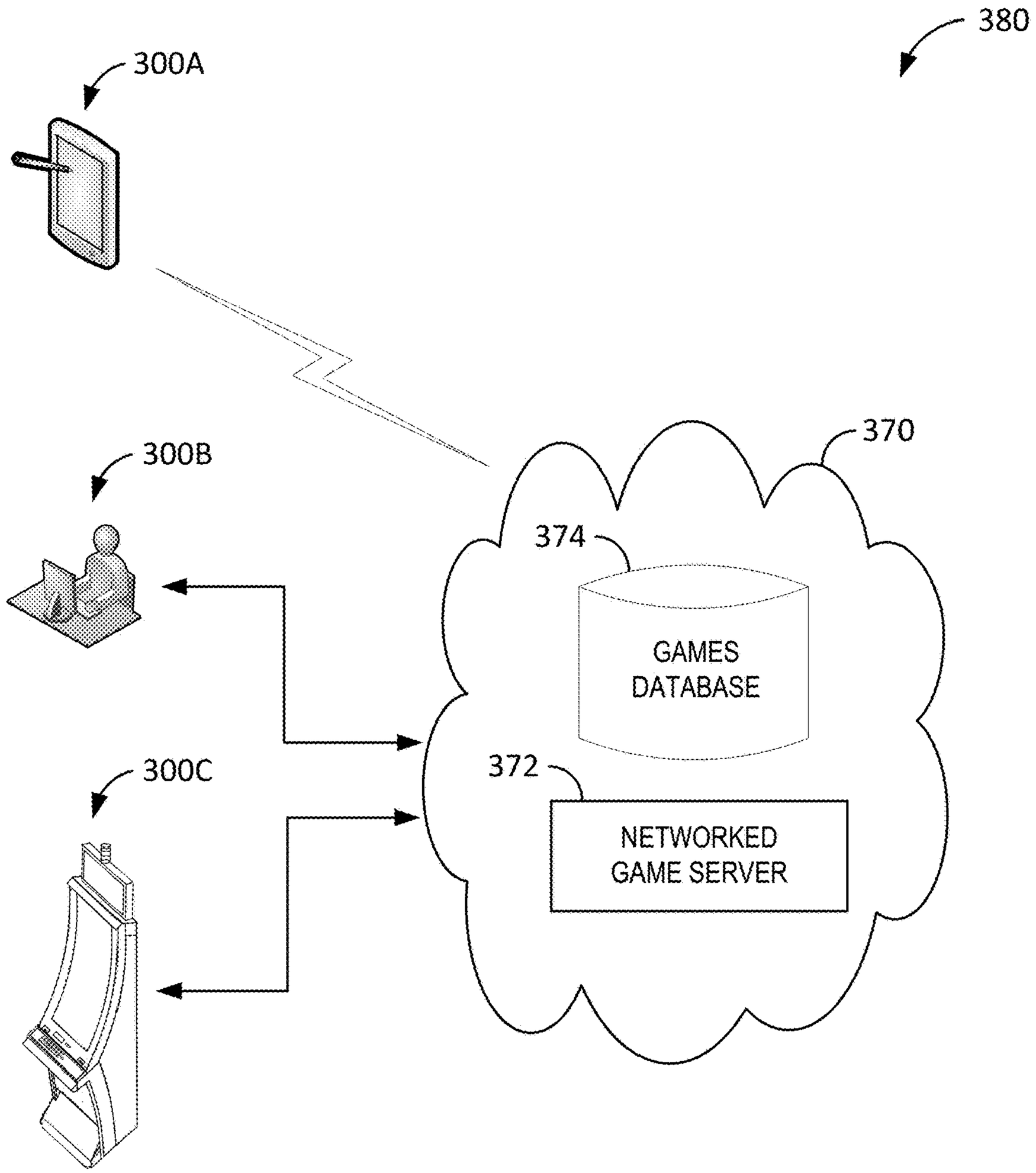

380
300A
300B
300C
370
374
GAMES
DATABASE
372
NETWORKED
GAME SERVER

FIG. 3B

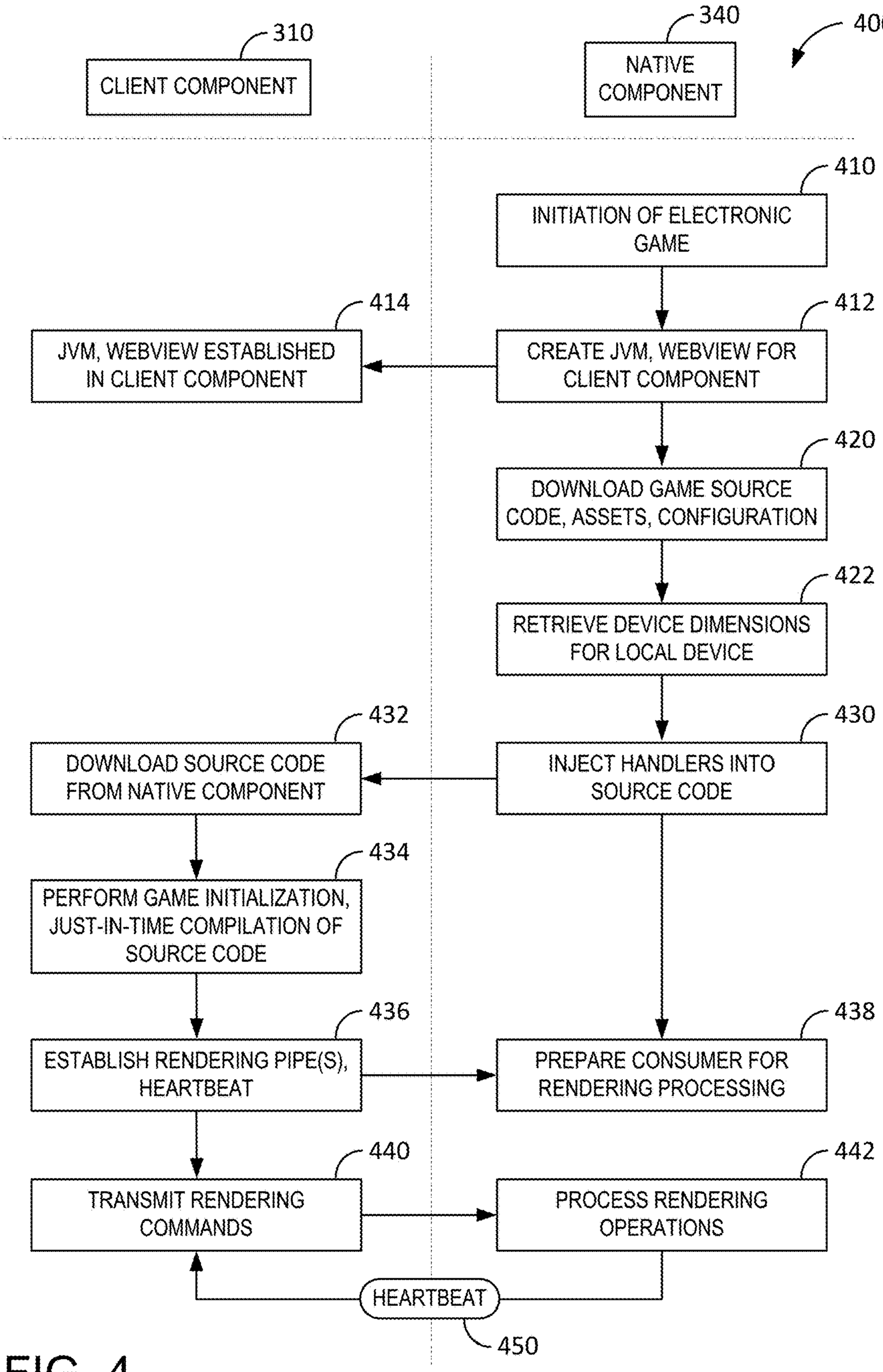

310
CLIENT COMPONENT
340
NATIVE COMPONENT
400
410
INITIATION OF ELECTRONIC GAME
414
JVM, WEBVIEW ESTABLISHED IN CLIENT COMPONENT
412
CREATE JVM, WEBVIEW FOR CLIENT COMPONENT
420
DOWNLOAD GAME SOURCE CODE, ASSETS, CONFIGURATION
422
RETRIEVE DEVICE DIMENSIONS FOR LOCAL DEVICE
432
DOWNLOAD SOURCE CODE FROM NATIVE COMPONENT
430
INJECT HANDLERS INTO SOURCE CODE
434
PERFORM GAME INITIALIZATION, JUST-IN-TIME COMPILATION OF SOURCE CODE
436
ESTABLISH RENDERING PIPE(S), HEARTBEAT
438
PREPARE CONSUMER FOR RENDERING PROCESSING
440
TRANSMIT RENDERING COMMANDS
442
PROCESS RENDERING OPERATIONS
HEARTBEAT
450

FIG. 4

RENDERING PIPELINE FOR ELECTRONIC GAMES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to U.S. Provisional Patent Application No. 62/959,407, filed 10 Jan. 2020, entitled "RENDERING PIPELINE FOR GAME ASSETS," and U.S. Provisional Patent Application No. 63/090,661, filed 12 Oct. 2020, entitled "RENDERING PIPELINE FOR ELECTRONIC GAMES, the entire contents and disclosures of which are hereby incorporated herein by reference in their entireties.

TECHNICAL FIELD

The field of disclosure relates generally to electronic gaming, and more particularly to electronic gaming systems and methods for providing a rendering pipeline for electronic games.

BACKGROUND

Electronic gaming machines (EGMs), or gaming devices, provide a variety of wagering games such as, for example, and without limitation, slot games, video poker games, video blackjack games, roulette games, video bingo games, keno games, and other types of games that are frequently offered at casinos and other locations. Play on EGMs typically involves a player establishing a credit balance by inserting or otherwise submitting money and placing a monetary wager (deducted from the credit balance) on one or more outcomes of an instance, or play, of a primary game, sometimes referred to as a base game. In many games, a player may qualify for secondary games or bonus rounds by attaining a certain winning combination or other triggering event in the base game. Secondary games provide an opportunity to win additional game instances, credits, awards, jackpots, progressives, etc. Awards from any winning outcomes are typically added back to the credit balance and can be provided to the player via a printed "ticket" upon completion of a gaming session or when the player wants to "cash out."

"Slot" type games are often displayed to the player in the form of various symbols arrayed in a row-by-column grid or matrix. Specific matching combinations of symbols along predetermined paths (or paylines) through the matrix indicate the outcome of the game. The display typically highlights winning combinations/outcomes for ready identification by the player. Matching combinations and their corresponding awards are usually shown in a "pay-table" which is available to the player for reference. Often, the player may vary his/her wager to include differing numbers of paylines and/or the amount bet on each line. By varying the wager, the player may sometimes alter the frequency or number of winning combinations, frequency or number of secondary games, and/or the amount awarded.

SUMMARY

In one aspect, an electronic gaming device providing a rendering pipeline for an electronic game is provided. The electronic gaming device includes a memory device storing the electronic game, a client component of the rendering pipeline, and a native component of the rendering pipeline. The electronic gaming device also includes a display device upon which video output of the electronic game is rendered. The electronic gaming device further includes at least one processor configured to execute the client component and the native component. The client component, when executed on the at least one processor, is configured to: initiate a rendering operations pipe between the client component and the native component; convert display commands from a source language of the electronic game into rendering operations of an intermediate rendering language; and transmit the rendering operations through the rendering operations pipe to the native component. The native component, when executed on the at least one processor, is configured to: receive the rendering operations via the rendering operations pipe; translate the rendering operations from the intermediate rendering language into rendering operations of the native component; and perform the rendering operations of the native component on the display device.

In another aspect, a method for providing a rendering pipeline for an electronic game on an electronic gaming device is provided. The electronic gaming device includes a memory device storing the electronic game, a client component of the rendering pipeline, and a native component of the rendering pipeline. The electronic gaming device also including a display device upon which video output of the electronic game is rendered. The electronic gaming device further includes at least one processor configured to execute the client component and the native component. The method includes establishing a rendering operations pipe between the client component and the native component. The method also includes converting, at the client component, display commands from a source language of the electronic game into rendering operations of an intermediate rendering language. The method further includes transmitting the rendering operations through the rendering operations pipe from the client component to the native component. The method also includes receiving, at the native component, the rendering operations via the rendering operations pipe. The method further includes translating the rendering operations from the intermediate rendering language into rendering operations of the native component. The method also includes performing the rendering operations of the native component on the display device.

In yet another aspect, a non-transitory computer-readable medium storing instructions is provided. The instructions, when executed by a processor of an electronic gaming device, cause a processor to: establish a rendering operations pipe between a client component and a native component; convert, at the client component, display commands from a source language of the electronic game into rendering operations of an intermediate rendering language; transmit the rendering operations through the rendering operations pipe from the client component to the native component; receive, at the native component, the rendering operations via the rendering operations pipe; translate the rendering operations from the intermediate rendering language into rendering operations of the native component; and perform the rendering operations of the native component on the display device.

BRIEF DESCRIPTION OF THE DRAWINGS

An example embodiment of the subject matter disclosed will now be described with reference to the accompanying drawings.

FIG. **1** is a diagram of exemplary EGMs networked with various gaming-related servers.

FIG. **2**A is a block diagram of an exemplary EGM.

FIG. **2**B illustrates an example gaming environment in which the gaming devices shown in FIGS. **1** and **2**A may appear.

FIG. **2**C is a diagram that shows examples of components of a system for providing online gaming according to some aspects of the present disclosure.

FIG. **3**A illustrates hardware components of a gaming device and data flow between components of a rendering pipeline executing on the device.

FIG. **3**B illustrates an example networked architecture in which the gaming devices may operate.

FIG. **4** is a swimlane diagram of an example method **400** for providing a rendering pipeline for an electronic game, such as the rendering pipeline **302** shown in FIG. **3**A.

DETAILED DESCRIPTION

Slot type games and other wager-type games (e.g., video poker, video keno, video roulette, and such) may be provided as either wagering games (e.g., for real value, or "value-based gaming") or as "social games" (e.g., using virtual currencies, no value virtual goods or currencies with no inherent value). Traditionally, wager games have been provided on highly regulated electronic gaming machines specifically designed for wager gaming venues (e.g., casino properties or other gambling establishments). As such wager gaming and social gaming has evolved, and the hardware platforms on which these games may be offered has expanded. For example, social games may be provided on personal computing devices, such as desktop computers or mobile computing devices (e.g., smart phones, tablets). In some jurisdictions, wager games may be permitted on mobile computing devices (e.g., when the mobile computing device is located within a sanctioned premises). These various hardware platforms may also provide varying operating system and software components that can be leveraged in game development. However, the expansion of available hardware platforms, operating systems, and associated software components upon which such electronic games may be provided also brings various design problems, such as software portability and performance issues across varying platforms and software stacks.

For example, a gaming company may wish to provide mobile games using current web technologies, such as programming their games in a just-in-time ("JIT") compiled language (e.g., JavaScript, Typescript), with the game's front end being designed to run in a web browser. To support such an architecture, WebGL and WebAudio components of the browser may be used to perform rendering functionality. However, such an architecture may be tightly coupled to the underlying rendering backend. Some environments may restrict use of particular tools, such as just-in-time compilers, forcing games to be implemented by an interpreter, which may cause performance to suffer.

In the example embodiment, a rendering pipeline architecture (or just "rendering pipeline") is provided for the execution of electronic games and, more particularly, for the rendering of game assets (e.g., video, audio, and the like). The rendering pipeline includes a client component ("front end") and a native component ("back end") installed on a gaming device, such as an EGM or a personal computing device (e.g., personal computer, mobile computing device). The client component executes the electronic game in a virtual machine (e.g., Java virtual machine ("JVM"), JavaScript engine, ECMAScript ("ES") engine) using a scripting language (e.g., JavaScript, Typescript) and, in the example embodiment, provides just-in-time ("JIT") compilation of some or all of the electronic game (e.g., as part of loading source into the JVM or a WebView). During execution of the electronic game, the client component uses a WebView object to parse and execute the electronic game, but redirects the display rendering through the rendering pipeline by generating and transmitting rendering operations, through one or more pipes, to the native component (e.g., a scene renderer of the Unity engine). The native component receives and processes these rendering operations from the pipe in order of receipt (e.g., as a first-in/first-out ("FIFO") pipe). In some embodiments, the native component may include a rendering tool such as the Unity Engine, and the native component is configured to convert the render commands from the pipe into the native rendering language on the local gaming device (e.g., into rendering commands via an API, such as OpenGL, Metal, Direct3D, or the like). The native component is responsible for communicating with the underlying operating system and associated hardware and subsystems of the executing device. The use of this rendering pipeline allows for separation of the electronic game from the particularities of the various underlying operating systems and hardware components of various gaming devices, allowing the game code to be developed and executed independent of such considerations. The native component is tailored to receive the rendering operations and perform those various operations on the specific hardware of the gaming device. This decoupling of the native rendering from the electronic game provides technical benefits including platform compatibility and independence from underlying rendering technologies which may change over time (e.g., OpenGL, Metal, or the like). Further, use of such an intermediate rendering language and separation of the game execution and the native rendering component allows for efficient, accurate, and effective game recording, compression, and replay of game sessions by, for example, recording the stream of rendering operations sent across the pipe. From such a recording, the game session can be recreated for viewing by replaying and reprocessing the stream of rendering operations (e.g., by sending the same rendering operations through the pipe to be processed as if the game were being executed by the client).

FIG. **1** illustrates several different models of EGMs which may be networked to various gaming related servers. Shown is a system **100** in a gaming environment including one or more server computers **102** (e.g., slot servers of a casino) that are in communication, via a communications network, with one or more gaming devices **104**A-**104**X (EGMs, slots, video poker, bingo machines, etc.) that can implement one or more aspects of the present disclosure. The gaming devices **104**A-**104**X may alternatively be portable and/or remote gaming devices such as, but not limited to, a smart phone, a tablet, a laptop, or a game console, although such devices may require specialized software and/or hardware to comply with regulatory requirements regarding devices used for wagering or games of chance in which monetary awards are provided.

Communication between the gaming devices **104**A-**104**X and the server computers **102**, and among the gaming devices **104**A-**104**X, may be direct or indirect, such as over the Internet through a web site maintained by a computer on a remote server or over an online data network including commercial online service providers, Internet service providers, private networks, and the like. In other embodiments, the gaming devices **104**A-**104**X may communicate with one another and/or the server computers **102** over RF, cable TV, satellite links and the like.

In some embodiments, server computers **102** may not be necessary and/or preferred. For example, in one or more embodiments, a stand-alone gaming device such as gaming device **104**A, gaming device **104**B or any of the other gaming devices **104**C-**104**X can implement one or more aspects of the present disclosure. However, it is typical to find multiple EGMs connected to networks implemented with one or more of the different server computers **102** described herein.

The server computers **102** may include a central determination gaming system server **106**, a ticket-in-ticket-out (TITO) system server **108**, a player tracking system server **110**, a progressive system server **112**, and/or a casino management system server **114**. Gaming devices **104**A-**104**X may include features to enable operation of any or all servers for use by the player and/or operator (e.g., the casino, resort, gaming establishment, tavern, pub, etc.). For example, game outcomes may be generated on a central determination gaming system server **106** and then transmitted over the network to any of a group of remote terminals or remote gaming devices **104**A-**104**X that utilize the game outcomes and display the results to the players.

Gaming device **104**A is often of a cabinet construction which may be aligned in rows or banks of similar devices for placement and operation on a casino floor. The gaming device **104**A often includes a main door **154** which provides access to the interior of the cabinet. Gaming device **104**A typically includes a button area or button deck **120** accessible by a player that is configured with input switches or buttons **122**, an access channel for a bill validator **124**, and/or an access channel for a ticket-out printer **126**.

In FIG. **1**, gaming device **104**A is shown as a Relm XL™ model gaming device manufactured by Aristocrat® Technologies, Inc. As shown, gaming device **104**A is a reel machine having a gaming display area **118** comprising a number (typically 3 or 5) of mechanical reels **130** with various symbols displayed on them. The reels **130** are independently spun and stopped to show a set of symbols within the gaming display area **118** which may be used to determine an outcome to the game.

In many configurations, the gaming machine **104**A may have a main display **128** (e.g., video display monitor) mounted to, or above, the gaming display area **118**. The main display **128** can be a high-resolution LCD, plasma, LED, or OLED panel which may be flat or curved as shown, a cathode ray tube, or other conventional electronically controlled video monitor.

In some embodiments, the bill validator **124** may also function as a "ticket-in" reader that allows the player to use a casino issued credit ticket to load credits onto the gaming device **104**A (e.g., in a cashless ticket ("TITO") system). In such cashless embodiments, the gaming device **104**A may also include a "ticket-out" printer **126** for outputting a credit ticket when a "cash out" button is pressed. Cashless TITO systems are used to generate and track unique bar-codes or other indicators printed on tickets to allow players to avoid the use of bills and coins by loading credits using a ticket reader and cashing out credits using a ticket-out printer **126** on the gaming device **104**A. The gaming machine **104**A can have hardware meters for purposes including ensuring regulatory compliance and monitoring the player credit balance. In addition, there can be additional meters that record the total amount of money wagered on the gaming machine, total amount of money deposited, total amount of money withdrawn, total amount of winnings on gaming device **104**A.

In some embodiments, a player tracking card reader **144**, a transceiver for wireless communication with a player's smartphone, a keypad **146**, and/or an illuminated display **148** for reading, receiving, entering, and/or displaying player tracking information is provided in EGM **104**A. In such embodiments, a game controller within the gaming device **104**A can communicate with the player tracking system server **110** to send and receive player tracking information.

Gaming device **104**A may also include a bonus topper wheel **134**. When bonus play is triggered (e.g., by a player achieving a particular outcome or set of outcomes in the primary game), bonus topper wheel **134** is operative to spin and stop with indicator arrow **136** indicating the outcome of the bonus game. Bonus topper wheel **134** is typically used to play a bonus game, but it could also be incorporated into play of the base or primary game.

A candle **138** may be mounted on the top of gaming device **104**A and may be activated by a player (e.g., using a switch or one of buttons **122**) to indicate to operations staff that gaming device **104**A has experienced a malfunction or the player requires service. The candle **138** is also often used to indicate a jackpot has been won and to alert staff that a hand payout of an award may be needed.

There may also be one or more information panels **152** which may be a back-lit, silkscreened glass panel with lettering to indicate general game information including, for example, a game denomination (e.g., $0.25 or $1), pay lines, pay tables, and/or various game related graphics. In some embodiments, the information panel(s) **152** may be implemented as an additional video display.

Gaming devices **104**A have traditionally also included a handle **132** typically mounted to the side of main cabinet **116** which may be used to initiate game play.

Many or all the above described components can be controlled by circuitry (e.g., a gaming controller) housed inside the main cabinet **116** of the gaming device **104**A, the details of which are shown in FIG. **2**A.

Note that not all gaming devices suitable for implementing embodiments of the present disclosure necessarily include top wheels, top boxes, information panels, cashless ticket systems, and/or player tracking systems. Further, some suitable gaming devices have only a single game display that includes only a mechanical set of reels and/or a video display, while others are designed for bar counters or table tops and have displays that face upwards.

An alternative example gaming device **104**B illustrated in FIG. **1** is the Arc™ model gaming device manufactured by Aristocrat® Technologies, Inc. Note that where possible, reference numerals identifying similar features of the gaming device **104**A embodiment are also identified in the gaming device **104**B embodiment using the same reference numbers. Gaming device **104**B does not include physical reels and instead shows game play functions on main display **128**. An optional topper screen **140** may be used as a secondary game display for bonus play, to show game features or attraction activities while a game is not in play, or any other information or media desired by the game designer or operator. In some embodiments, topper screen **140** may also or alternatively be used to display progressive jackpot prizes available to a player during play of gaming device **104**B.

Example gaming device **104**B includes a main cabinet **116** including a main door **154** which opens to provide access to the interior of the gaming device **104**B. The main or service door **154** is typically used by service personnel to refill the ticket-out printer **126** and collect bills and tickets

inserted into the bill validator **124**. The main or service door **154** may also be accessed to reset the machine, verify and/or upgrade the software, and for general maintenance operations.

Another example gaming device **104**C shown is the Helix™ model gaming device manufactured by Aristocrat® Technologies, Inc. Gaming device **104**C includes a main display **128**A that is in a landscape orientation. Although not illustrated by the front view provided, the landscape display **128**A may have a curvature radius from top to bottom, or alternatively from side to side. In some embodiments, display **128**A is a flat panel display. Main display **128**A is typically used for primary game play while secondary display **128**B is typically used for bonus game play, to show game features or attraction activities while the game is not in play or any other information or media desired by the game designer or operator. In some embodiments, example gaming device **104**C may also include speakers **142** to output various audio such as game sound, background music, etc.

Many different types of games, including mechanical slot games, video slot games, video poker, video black jack, video pachinko, keno, bingo, and lottery, may be provided with or implemented within the depicted gaming devices **104**A-**104**C and other similar gaming devices. Each gaming device may also be operable to provide many different games. Games may be differentiated according to themes, sounds, graphics, type of game (e.g., slot game vs. card game vs. game with aspects of skill), denomination, number of paylines, maximum jackpot, progressive or non-progressive, bonus games, and may be deployed for operation in Class 2 or Class 3, etc.

FIG. **2**A is a block diagram depicting exemplary internal electronic components of a gaming device **200** connected to various external systems. All or parts of the example gaming device **200** shown could be used to implement any one of the example gaming devices **104**A-X depicted in FIG. **1**. The games available for play on the gaming device **200** are controlled by a game controller **202** that includes one or more processors **204** and a game that may be stored as game software or a program **206** in a memory **208** coupled to the processor **204**. The memory **208** may include one or more mass storage devices or media that are housed within gaming device **200**. Within the mass storage devices and/or memory **208**, one or more databases **210** may be provided for use by the program **206**. A random number generator (RNG) **212** that can be implemented in hardware and/or software is typically used to generate random numbers that are used in the operation of game play to ensure that game play outcomes are random and meet regulations for a game of chance.

Alternatively, a game instance (i.e. a play or round of the game) may be generated on a remote gaming device such as a central determination gaming system server **106** (not shown in FIG. **2**A but see FIG. **1**). The game instance is communicated to gaming device **200** via the network **214** and then displayed on gaming device **200**. Gaming device **200** may execute game software, such as but not limited to video streaming software that allows the game to be displayed on gaming device **200**. When a game is stored on gaming device **200**, it may be loaded from a memory **208** (e.g., from a read only memory (ROM)) or from the central determination gaming system server **106** to memory **208**. The memory **208** may include RAM, ROM or another form of storage media that stores instructions for execution by the processor **204**.

The gaming device **200** may include a topper display **216** or another form of a top box (e.g., a topper wheel, a topper screen, etc.) which sits above cabinet **218**. The cabinet **218** or topper display **216** may also house a number of other components which may be used to add features to a game being played on gaming device **200**, including speakers **220**, a ticket printer **222** which prints bar-coded tickets or other media or mechanisms for storing or indicating a player's credit value, a ticket reader **224** which reads bar-coded tickets or other media or mechanisms for storing or indicating a player's credit value, and a player tracking interface **232**. The player tracking interface **232** may include a keypad **226** for entering information, a player tracking display **228** for displaying information (e.g., an illuminated or video display), a card reader **230** for receiving data and/or communicating information to and from media or a device such as a smart phone enabling player tracking. Ticket printer **222** may be used to print tickets for a TITO system server **108**. The gaming device **200** may further include a bill validator **234**, player-input buttons **236** for player input, cabinet security sensors **238** to detect unauthorized opening of the cabinet **218**, a primary game display **240**, and a secondary game display **242**, each coupled to and operable under the control of game controller **202**.

Gaming device **200** may be connected over network **214** to player tracking system server **110**. Player tracking system server **110** may be, for example, an OASIS® system manufactured by Aristocrat® Technologies, Inc. Player tracking system server **110** is used to track play (e.g. amount wagered, games played, time of play and/or other quantitative or qualitative measures) for individual players so that an operator may reward players in a loyalty program. The player may use the player tracking interface **232** to access his/her account information, activate free play, and/or request various information. Player tracking or loyalty programs seek to reward players for their play and help build brand loyalty to the gaming establishment. The rewards typically correspond to the player's level of patronage (e.g., to the player's playing frequency and/or total amount of game plays at a given casino). Player tracking rewards may be complimentary and/or discounted meals, lodging, entertainment and/or additional play. Player tracking information may be combined with other information that is now readily obtainable by a casino management system.

Gaming devices, such as gaming devices **104**A-**104**X, **200**, are highly regulated to ensure fairness and, in many cases, gaming devices **104**A-**104**X, **200** are operable to award monetary awards (e.g., typically dispensed in the form of a redeemable voucher). Therefore, to satisfy security and regulatory requirements in a gaming environment, hardware and software architectures are implemented in gaming devices **104**A-**104**X, **200** that differ significantly from those of general-purpose computers. Adapting general purpose computers to function as gaming devices **200** is not simple or straightforward because of: 1) the regulatory requirements for gaming devices **200**, 2) the harsh environment in which gaming devices **200** operate, 3) security requirements, 4) fault tolerance requirements, and 5) the requirement for additional special purpose componentry enabling functionality of an EGM. These differences require substantial engineering effort with respect to game design implementation, hardware components and software.

When a player wishes to play the gaming device **200**, he/she can insert cash or a ticket voucher through a coin acceptor (not shown) or bill validator **234** to establish a credit balance on the gamine machine. The credit balance is used by the player to place wagers on instances of the game

and to receive credit awards based on the outcome of winning instances. The credit balance is decreased by the amount of each wager and increased upon a win. The player can add additional credits to the balance at any time. The player may also optionally insert a loyalty club card into the card reader **230**. During the game, the player views the game outcome on one or more of the primary game display **240** and secondary game display **242**. Other game and prize information may also be displayed.

For each game instance, a player may make selections, which may affect play of the game. For example, the player may vary the total amount wagered by selecting the amount bet per line and the number of lines played. In many games, the player is asked to initiate or select options during course of game play (such as spinning a wheel to begin a bonus round or select various items during a feature game). The player may make these selections using the player-input buttons **236**, the primary game display **240** which may be a touch screen, or using some other device which enables a player to input information into the gaming device **200**.

During certain game events, the gaming device **200** may display visual and auditory effects that can be perceived by the player. These effects add to the excitement of a game, which makes a player more likely to enjoy the playing experience. Auditory effects include various sounds that are projected by the speakers **220**. Visual effects include flashing lights, strobing lights or other patterns displayed from lights on the gaming device **200** or from lights behind the information panel **152** (FIG. **1**).

When the player is done, he/she cashes out the credit balance (typically by pressing a cash out button to receive a ticket from the ticket printer **222**). The ticket may be "cashed-in" for money or inserted into another machine to establish a credit balance for play.

While an example gaming device **200** has been described in regard to FIG. **2**A, certain aspects of the present disclosure may be implemented by gaming devices that lack one or more of the above-described components. For example, not all gaming devices suitable for implementing aspects of the present disclosure necessarily include top boxes, information panels, cashless ticket systems, and/or player tracking systems. Further, some suitable gaming devices may include a single game display having mechanical reels or a video display. Moreover, other embodiments may be designed for bar tables and have displays that face upwards.

Many different types of wagering games, including mechanical slot games, video slot games, video poker, video blackjack, video pachinko, keno, bingo, and lottery, may be provided by the gaming device **200**. In particular, the gaming device **200** may be operable to provide many different instances of games of chance. The instances may be differentiated according to themes, sounds, graphics, type of game (e.g., slot game vs. card game vs. game with aspects of skill), denomination, number of paylines, maximum jackpot, progressive or non-progressive, bonus games, class 2 or class 3, etc.

The gaming device **200** may allow a player to select a game of chance, skill, or combination thereof, to play from a plurality of instances available on the gaming device **200**. For example, the gaming device **200** may provide a menu with a list of the instances of games that are available for play on the gaming device **200** and a player may be able to select, from the list, a game that they wish to play.

FIG. **2**B illustrates an example gaming environment **250** in which the gaming devices **104**, **200** shown in FIGS. **1** and **2**A may appear. In the example embodiment, the gaming environment **250** is a physical venue of a casino that includes banks **252** of gaming devices **104**. In this example, each bank **252** of gaming devices **104** includes a corresponding gaming signage system **254**. In this example, the gaming environment **250** includes a gaming table (e.g., a "smart table") **294** that is configured for table gaming. The gaming environment **250** also includes mobile gaming devices **256** which, in various embodiments, may present wagering games or social games. The mobile gaming devices **256** may, for example, include tablet devices, cellular phones, smart phones, or other handheld computing devices. In this example, the mobile gaming devices **256** are configured for communication with one or more other devices in the gaming environment **250**, including but not limited to one or more of the gaming devices **104**, one or more smart tables **294**, one or more kiosk(s) **260**, and one or more of the server computers **102**, via wireless access points **258**. In some implementations, the mobile gaming devices **256** may be configured for communication with one or more other devices in the gaming environment **250**, including but not limited to one or more of the gaming devices **104**, one or more smart tables **294**, one or more kiosk(s) **260**, via wireless communications (e.g., near-field communication (NFC), Bluetooth, Wi-Fi, or such, via one of the "beacons" described herein).

According to some examples, the mobile gaming devices **256** may be configured for stand-alone determination of game outcomes. However, in some alternative implementations the mobile gaming devices **256** may be configured to receive game outcomes from another device, such as a central determination gaming system server (not separately shown), one of the gaming devices **104**, etc.

Some mobile gaming devices **256** may be configured to accept monetary credits from a credit or debit card, via a wireless interface (e.g., via a wireless payment app), via tickets, via a patron casino account, etc. However, some mobile gaming devices **256** may not be configured to accept monetary credits via a credit or debit card. Some mobile gaming devices **256** may include a ticket reader and/or a ticket printer whereas some mobile gaming devices **256** may not, depending on the particular implementation.

In some embodiments, the gaming environment **250** may include one or more kiosks **260** that are configured to facilitate monetary transactions involving the mobile gaming devices **256**, which may include cash out and/or cash in transactions. The kiosk(s) **260** may be configured for wired and/or wireless communication with the mobile gaming devices **256**. The kiosk(s) **260** may be configured to accept monetary credits from casino patrons **262** or to dispense monetary credits to casino patrons **262** via cash, a credit or debit card, via a wireless interface (e.g., via a wireless payment app), via tickets, digital wallet, or such. According to some examples, the kiosk(s) **260** may be configured to accept monetary credits from a casino patron and to provide a corresponding amount of monetary credits to a mobile gaming device **256** for wagering purposes (e.g., via a wireless link such as an NFC link). In some such examples, when a casino patron **262** is ready to cash out, the casino patron **262** may select a cash out option provided by the mobile gaming device **256**, which may include a real button or a virtual button (e.g., a button provided via a graphical user interface) in some instances. In some such examples, the mobile gaming device **256** may send a "cash out" signal to the kiosk **260** via a wireless link in response to receiving a "cash out" indication from a casino patron. The kiosk **260** may provide monetary credits to the patron **262** corresponding to the "cash out" signal, which may be in the form of

cash, a credit ticket, a credit transmitted to a financial account corresponding to the casino patron, a digital wallet account, or such.

In some implementations, a cash-in process and/or a cash-out process may be facilitated by the TITO system server **108**. For example, the TITO system server **108** may control, or at least authorize, ticket-in and ticket-out transactions that involve a mobile gaming device **256** and/or a kiosk **260**.

Some mobile gaming devices **256** may be configured for receiving and/or transmitting player loyalty information. For example, some mobile gaming devices **256** may be configured for wireless communication with the player tracking system server **110**. Some mobile gaming devices **256** may be configured for receiving and/or transmitting player loyalty information via wireless communication with a patron's player loyalty card, a patron's smartphone, etc.

According to some implementations, a mobile gaming device **256** may be configured to provide safeguards that prevent the mobile gaming device **256** from being used by an unauthorized person. For example, some mobile gaming devices **256** may include one or more biometric sensors and may be configured to receive input via the biometric sensor(s) to verify the identity of an authorized patron. Some mobile gaming devices **256** may be configured to function only within a predetermined or configurable area, such as within a casino gaming area (e.g., based on GPS and geofencing).

FIG. **2**C is a diagram that shows examples of components of a system for providing online gaming according to some aspects of the present disclosure. As with other figures presented in this disclosure, the numbers, types and arrangements of gaming devices shown in FIG. **2**C are merely shown by way of example. In the example embodiment, various gaming devices, including but not limited to end user devices (EUDs) **264***a*, **264***b* and **264***c* are capable of communication via one or more networks **292**. The networks **292** may, for example, include one or more cellular telephone networks, the Internet, Wi-Fi networks, satellite networks, or such. In this example, the EUDs **264***a* and **264***b* are mobile devices. For example, the EUD **264***a* may be a tablet device and the EUD **264***b* may be a smart phone. The EUD **264***c* is a laptop computer that is located within a residence **266** at the time depicted in FIG. **2**C. Accordingly, in this example the hardware of EUDs **264** is not specifically configured for online gaming, although each EUD **264** is configured with software for online gaming. For example, each EUD **264** may be configured with a web browser, installed gaming applications, player apps, or such. Other implementations may include other types of EUD **264**, some of which may be specifically configured for online gaming.

In this example, a gaming data center **276** includes various devices that are configured to provide online wagering games or social games via the networks **292**. The gaming data center **276** is capable of communication with the networks **292** via the gateway **272**. In this example, switches **278** and routers **280** are configured to provide network connectivity for devices of the gaming data center **276**, including storage devices **282***a*, servers **284***a* and one or more workstations **286***a*. The servers **284***a* may, for example, be configured to provide access to a library of games for online game play or for download and installation by remote devices (e.g., EUDs **264**). In some examples, code for executing at least some of the games may initially be stored on one or more of the storage devices **282***a*. The code may be subsequently loaded onto a server **284***a* after selection by a player via an EUD **264** and communication of that selection from the EUD **264** via the networks **292**. The server **284***a* onto which code for the selected game has been loaded may provide the game according to selections made by a player and indicated via the player's EUD **264**. In other examples, code for executing at least some of the games may initially be stored on one or more of the servers **284***a*. Although only one gaming data center **276** is shown in FIG. **2**C, some implementations may include multiple gaming data centers **276**.

In this example, a financial institution data center **270** is also configured for communication via the networks **292**. Here, the financial institution data center **270** includes servers **284***b*, storage devices **282***b*, and one or more workstations **286***b*. According to this example, the financial institution data center **270** is configured to maintain financial accounts, such as checking accounts, savings accounts, loan accounts, payment card accounts, rewards accounts, loyalty accounts, player accounts, digital wallet accounts, or such. In some implementations one or more of the authorized users **274***a*-**274***c* may maintain at least one financial account with the financial institution that is serviced via the financial institution data center **270**.

According to some implementations, the gaming data center **276** may be configured to provide online wagering games in which money may be won or lost, or various social games, some of which may use virtual currencies. According to some such implementations, one or more of the servers **284***a* may be configured to monitor player credit balances, which may be expressed in game credits, in real or virtual currency units, or in any other appropriate manner. In some implementations, the server(s) **284***a* may be configured to obtain financial credits from and/or provide financial credits to one or more financial institutions, according to a player's "cash in" selections, wagering game results and a player's "cash out" instructions. According to some such implementations, the server(s) **284***a* may be configured to electronically credit or debit the account of a player that is maintained by a financial institution, e.g., an account that is maintained via the financial institution data center **270**. The server(s) **284***a* may, in some examples, be configured to maintain an audit record of such transactions.

In some embodiments, the gaming data center **276** may be configured to provide online wagering games for which credits may not be exchanged for cash or the equivalent. In some such examples, players may purchase game credits for online game play, but may not "cash out" for monetary credit after a gaming session. Moreover, although the financial institution data center **270** and the gaming data center **276** include their own servers and storage devices in this example, in some examples the financial institution data center **270** and/or the gaming data center **276** may use offsite "cloud-based" servers and/or storage devices. In some alternative examples, the financial institution data center **270** and/or the gaming data center **276** may rely entirely on cloud-based servers.

One or more types of devices in the gaming data center **276** (or elsewhere) may be capable of executing middleware, e.g., for data management and/or device communication. Authentication information, player tracking information, etc., including but not limited to information obtained by EUDs **264** and/or other information regarding authorized users of EUDs **264** (including but not limited to the authorized users **274***a*-**274***c*), may be stored on storage devices **282** and/or servers **284**. Other game-related information and/or software, such as information and/or software relating to leaderboards, players currently playing a game, game themes, game-related promotions, game competitions, etc.,

also may be stored on storage devices **282** and/or servers **284**. In some implementations, some such game-related software may be available as "apps" and may be downloadable (e.g., from the gaming data center **276**) by authorized users.

In some examples, authorized users and/or entities (such as representatives of gaming regulatory authorities) may obtain gaming-related information via the gaming data center **276**. One or more other devices (such EUDs **264** or devices of the gaming data center **276**) may act as intermediaries for such data feeds. Such devices may, for example, be capable of applying data filtering algorithms, executing data summary and/or analysis software, etc. In some implementations, data filtering, summary and/or analysis software may be available as "apps" and downloadable by authorized users.

In some embodiments, the financial institution data center **270** may be configured for communication with one or more devices in the gaming environment **250**. As noted above, the mobile gaming devices **256** may or may not be specialized gaming devices, depending on the particular implementation. In some examples, the mobile gaming devices **256** may be end user devices (EUDs **264**), such as tablet devices, cellular phones, smart phones and/or other handheld devices.

In some embodiments, the gaming environment **250** may include one or more kiosks **260**. According to some implementations, the kiosk(s) **260** may be part of the digital wallet management server **290** even though in FIG. **2**B the kiosk(s) **260** and the digital wallet management server **290** are shown separately. The kiosk(s) **260** may be configured for communication with other devices of the digital wallet management server **290** (e.g., with one or more servers of the digital wallet management server **290**), for example, to allow digital wallet-based transactions at the kiosk **260** (e.g., purchasing credits from a digital wallet account to cash or to a TITO ticket, redeeming a TITO ticket to a digital wallet account, redeeming a reward stored in a digital wallet).

In some embodiments, the kiosk(s) **260** may be configured to facilitate monetary transactions involving a digital wallet (e.g., monetary transactions involving digital wallet software being executed by one or more of the mobile gaming devices **256**). Such transactions may include, but are not limited to, cash out and/or cash in transactions. The kiosk(s) **260** may be configured for wired and/or wireless communication with the mobile gaming devices **256**. The kiosk(s) **260** may be configured to accept monetary credits from casino patrons **262** and/or to dispense monetary credits to casino patrons **262** via cash, a credit or debit card, via a wireless interface (e.g., via a wireless payment app), via tickets, etc. Accordingly, in some such examples, the kiosk(s) **260** may be configured for communication with one or more financial institution data centers.

In some embodiments, the kiosk(s) **260** may be configured to accept monetary credits from a casino patron and to provide a corresponding amount of monetary credits to a mobile gaming device **256** for wagering purposes (e.g., via a wireless link such as a near-field communications link). According to some implementations, a digital wallet app running on one of the mobile gaming devices **256** (e.g., on a patron's cell phone) may be configured for wireless communication with gaming devices **104**, smart tables **294**, or such (e.g., to provide digital wallet-based, cashless "cash-out" and/or "cash-in" transactions at location). In some such examples, when a casino patron **262** is ready to cash out, the casino patron **262** may select a cash out option provided by a mobile gaming device **256**, which may include a real button or a virtual button (e.g., a button provided via a graphical user interface) in some instances. In some such examples, the mobile gaming device **256** may send a "cash out" signal to a kiosk **260** via a wireless link in response to receiving a "cash out" indication from a casino patron. The kiosk **260** may provide monetary credits to the patron **262** corresponding to the "cash out" signal, which may be in the form of cash, a credit ticket, a credit transmitted to a financial account corresponding to the casino patron, etc.

In some examples, at least some of the mobile gaming devices **256** may be configured for implementing digital wallet transactions with a gaming device **104** or a smart table **294** via Bluetooth or NFC. According to some implementations, the gaming device **104** or smart table **294** may be configured to provide a Bluetooth low-energy (LE) beacon for establishing wireless communication with at least some of the mobile gaming devices **256**. In some implementations, the mobile gaming device **256** may implement digital wallet transactions (such as cash in or cash out transactions) with the gaming device **104** or smart table **294** directly, via NFC or Bluetooth. In other implementations, the gaming device **104** or smart table **294** may be able to transmit communications to a mobile gaming device via NFC or the Bluetooth (LE) beacon, but the mobile gaming device may be required to provide input to the gaming device **104** or smart table **294** indirectly (e.g., via one or more devices of a player loyalty system or of a digital wallet management system).

Some embodiments provide alternative methods of establishing a "cardless" connection between a mobile gaming device and an EGM **104** or a smart table **294**. In some such implementations, a player tracking interface of the gaming device **104** or smart table **294** may be configured to establish a wireless connection and a cardless player tracking session with a mobile gaming device. For example, the gaming device **104** may be configured to establish a wireless connection and a cardless player tracking session with a mobile gaming device via the player tracking interface **232** that is described above with reference to FIG. **2**A. A smart table **294** may be configured to establish a wireless connection and a cardless player tracking session with a mobile gaming device.

In some examples, a player tracking interface of the gaming device **104** or smart table **294** may be configured for wireless communication with a mobile gaming device (e.g., via Bluetooth or NFC). In some such examples, the player tracking interface may include a user interface (e.g., a GUI or a physical button) with which a player can interact in order to obtain a passcode from the player tracking interface. The passcode may, for example, be an RNG code. The passcode may be provided to the player via a display of the player tracking interface. The player may be required to input the code (e.g., via the mobile gaming device) in order to pair the mobile gaming device with the player tracking interface and enable digital wallet transactions with the EGM or the smart table. According to some such implementations, a "cardless" player loyalty session may also be established when the mobile gaming device is paired with the player tracking interface.

FIG. **3**A illustrates hardware components of a gaming device **300** and data flow between components of a rendering pipeline **302** executing on the device **300**. In some embodiments, the gaming device **300** is an electronic gaming machine, such as gaming devices **104**, **200**. In the example embodiment, the gaming device **300** is a personal computing device of a player, such as a mobile computing device (e.g., smart phone, tablet) or a personal computer. In

some embodiments, the gaming device **300** may be similar to the mobile gaming devices **256** shown in FIG. **2**B or the end user devices **264** shown in FIG. **2**C. The gaming device **300** includes a memory device **304** (e.g., RAM memory, solid state drive, or other such transitory and/or non-transitory storage media) that stores various components used to execute an electronic game, represented here as electronic game component **306**, as well as components of the rendering pipeline **302** (e.g., a client component **310** and a native component **340**). The gaming device **300** also includes other device hardware **360** specific to the particular device **300**, and may vary considerably in various hardware components, configurations, and settings. In this example, the device hardware **360** includes one or more processors **362** (e.g., processor **203**, central processing unit ("CPU") of a personal computing device, or such), one or more display devices **364** (e.g., game displays **240**, **242**, touch screen display of a mobile device, desktop display device of a personal desktop computer, or the like), one or more audio devices **366** (e.g., speakers **220**), and one or more input/output ("I/O") devices **368** (e.g., buttons **236**, touch screen surface of a mobile device, keyboard and mouse of a personal desktop computer, or the like). While components of the rendering pipeline **302** are illustrated here as a part of the memory device **304**, it should be understood that these components are executed by a processor, such as processors **362**, game controller **202**, or such, and FIG. **3**A illustrates aspects of data flow of the rendering pipeline **302** for purposes of describing various embodiments. Further, it should be understood that the gaming device **300** may include an operating system (not separately depicted for ease of illustration, e.g., Windows, Android, iOS, or the like) and the native component **340** may perform various interactions with the device hardware **360** via interactions with the operating system and various underlying device drivers (also not separately depicted). In addition, the client component **310** of the example embodiment includes a virtual machine (e.g., JVM, not separately depicted) that is configured to perform JIT compilation and execution of the electronic game component **306**. In some embodiments, the client component **310** is executed within a virtual machine instantiated by the native component.

The client component **310** receives the electronic game component **306** for execution on the gaming device **300**. In the example embodiment, the electronic game component **306** is an electronic game developed in JavaScript or Type-script ("game source code"), and the client component **310** includes a Java virtual machine ("JVM") (not separately depicted) that can execute the game source code. The client component **310** may create a WebView object (e.g., an embedded web browser, not separately depicted, installed and executing on the gaming device **300**) that is configured to execute game source code in the WebView (e.g., via offscreen WebKit rendering). The client component **310** receives the electronic game component **306** in game source code (e.g., JavaScript source) and executes the game component **306** through the JVM. For example, when some external event occurs, such as user selection of a game from a lobby of possible games, the game source code may be received and inserted as a <script> tag/object into a Document Object Model ("DOM") of an IFRAME. The WebView object then renders the DOM, which in turn executes the game component **306**. More specifically, the client component **310** performs just-in-time compilation on any uncompiled code needed to execute the game component **306** and executes the compiled game. The game script installs a handler in the globals space on a 'requestAnimationFrame' ("RAF") event. This event is scheduled to periodically fire at the WebView's discretion (e.g., 15 to 60 frames per second, based on a shared heartbeat **336** provided by the native component **340**). This RAF event drives the game and provides smooth animations.

The electronic game component **306** provides and utilizes various game assets during game play, including timelines **322**, sprites **324**, and textures **326** that are used to provide aspects of game play. In some embodiments, the electronic game is a slot style game provided in a wagering environment (e.g., involving wagering for value) or a social environment (e.g., using virtual currencies of no intrinsic value). During game initiation and execution, an asset loader **314** constructs various game objects such as timelines **322**, sprites **324**, and textures **326**. The client component **310** then uses these nodes to construct the layout and the behavior of the game **306**. Some such game objects may require game assets that need to be rendered during game execution (e.g., digital video assets, audio assets, or the like). The native component **340** is ultimately responsible for rendering the assets to the screen. As such, the client component **310** orchestrates when a new asset is loaded and commands the native component **340** to load up the raw materials of the assets. More specifically, an asset manager **312** of the client component **310** generates and transmits loading operations **334** (e.g., commands) to an asset manager **350** of the native component **340** as new assets are needed by the executing game. The native component **340** provides the asset loader **314**. As part of game execution, the client component **310** transmits loading operations **334** to the asset loader **314** instructing the native component **340** which assets to load into memory as part of game execution (e.g., from non-transient storage into transient storage, RAM memory of the executing process). Game assets can be grouped into nodes and materials. Nodes represent elements that the game uses to control how the game will look (e.g., drawing a sprite node of an 'Ace' symbol at position X, size Z, color C, and opacity O). The actual image for the 'Ace' is in a material called a texture. Nodes may include timelines **322**, text, sprites **324**, sounds, or the like. Materials may include audio clips, fonts, textures, video textures, image sequences, or the like. During operation, the client component **310** loads nodes for a given asset, and the native component **340** loads materials for the given asset (e.g., via the asset manager **350** and asset loader **314**).

During game play, in the example embodiment, the client component **310** executes the electronic game on the gaming device **300** as the front end component of the pipeline **302**. In some embodiments, the gaming device **300** provides a virtual 'lobby' (not shown) through which the player may select a particular game for execution. When a particular game is selected through the lobby, the native component **340** downloads the selected game and initiates setup and execution of the game (e.g., game component **306**). In some embodiments, the native component **340** downloads the electronic game and all associated components (e.g., game source code, game assets, or the like) from a remote games library such as the games database **374** shown in FIG. **3**B. The native component **340** stores some game assets (e.g., materials) in a fonts library **352**, texture library **354**, and sound library **356** for potential use during game execution.

The electronic game assets also include game source code (e.g., JavaScript). The native component **340**, in the example embodiment, inserts handlers into the game source code that, upon execution in the client component **310**, will cause the client component **310** to establish the rendering pipe **332** and transmit rendering operations **330** to the native component **340**. After modification of the game source code, the

native component **340** creates a virtual machine and causes the game source code to execute within that virtual machine (e.g., in an offscreen WebKit). This virtual machine that executes the game source code becomes the client component **310** of the rendering pipeline **302** shown in FIG. **3**A. During execution of the game source code, the native component **340** establishes a heartbeat **336** that is configured at a particular frequency (e.g., 15-60 frames per second). This heartbeat **336** is used to dictate, to the client component **310**, how frequently to generate and send rendering operations **330** to the native component **340**. The client component **310** establishes connections to the native component **340** (e.g., pipe **332** for rendering operations **330**, and perhaps another connection for loading operations **334**) and begins executing the game. After these connections are established, game execution includes attaching the game to RAF event, which will give the game a periodic heartbeat consistent with the heartbeat **336**. The game performs initialization logic which loads up the assets needed for the initial scene. Some operations of the electronic game component **306** utilize audio and visual display functionality for purposes of presenting aspects of the game to the player (referred to herein as "source operations" or "source output operations"). To facilitate game execution, the render pipeline **302** provides a render language ("RL") that is used by the client component **310** to send rendering operations **330** to the native component **340** for processing. These rendering operation **330** may be referred to herein as "intermediate rendering operations", in distinction to native rendering operations which may be sent to a graphical renderer **344**, video decoder **346**, or audio subsystem **348** for presentation by device hardware **360**. To facilitate such intermediate rendering operations, the client component **310** provides a render language producer **320** that is configured to generate streams of rendering operations **330** based on the configuration and instructions of the electronic game component **306** and associated assets (e.g., based on the source output operations of the electronic game component **306**). RL producer **320** creates these rendering operations **330** in a text-based intermediate rendering language described in further detail below. These rendering operations are subsequently received by the native component **340**. Upon receipt of a particular set of rendering operations **330**, the rendering operations **330** are performed by a render language consumer **342** on the native component **340** (e.g., processed as FIFO operations as received). In the example embodiment, the render language consumer **342** translates each of the rendering operations **330** from the intermediate rendering language into native rendering operations of a native backend renderer **370** (e.g., OpenGL, Metal, Direct3D) of the gaming device **300**. Such native rendering operations may include API calls in native rendering operations for that particular backend renderer **370**. As the render language consumer **342** submits these native rendering operations **330** to the backend renderer **370**, the backend renderer **370** interacts with the device hardware **360** to perform the rendering operations **330** on the native device hardware **360** (e.g., through various sub-components of the gaming device **300**, such as a graphical renderer **344**, a video decoder **346**, an audio subsystem **348**, and the like). As such, the rendering operations **330** generated by the client component **310** are translated into native operations that can be presented on the local hardware, thereby exhibiting the various technical advantages described herein, including a rendering language that is API-agnostic to the particular backend renderers **370** provided on various disparate types of gaming devices **300**.

For example, in some embodiments, the electronic game component **306** may include JavaScript code that provides timeline operations during execution of the game (e.g., that certain timelines are played, stopped, paused, and so forth). The client component **310** converts such timeline operations into an internal node representation (e.g., Text2D, Sprite2D, and so forth). These nodes contain internal state information used to present game objects (e.g., transforms representing position, rotation, scale, vectors representing color, and so forth). The client component **310** may build a scene graph for the game. In the example embodiment, the client component **310** serializes this scene graph via corresponding intermediate rendering operations (e.g., Sprite2D, Text2D) and send this stream to the render language consumer **342** (e.g., as rendering operations **330** in pipe **332**). The render language consumer **342** deserializes the stream of rendering operations **330**, building its own internal representation of the node objects and creating a corresponding scene graph on the native side (e.g., in the native component **340**). For example, Sprite2D commands may get converted into a series of mesh, vertex, triangle lists, and UVs. These native rendering operations (e.g., in a format that Unity3D understands) may be sent to the graphics and audio devices **364**, **366** (e.g., after any final Unity3D to low-level API conversions). Further, the consumer **342** may also keep track of all objects on a frame-by-frame basis utilizing a unique element ID. This may be used to modify already existing objects that may have moved from one frame to the next and also perform garbage collection or object recycling if a particular object is absent from one frame to the next. This allows the native component **340** to run with minimized memory consumption and greater memory efficiency

In some embodiments, the graphical renderer **344**, video decoder **346**, and audio subsystem **348** are provided by a third-party rendering engine, such as the Unity Engine, which abstracts away from the native component **340** certain hardware-specific details of the local device hardware **360** (e.g., interaction with particular display devices **364**, audio devices **366**, and I/O devices **368**), and the native component **340** is implemented as an extension (e.g., plug-in) of the third-party rendering engine **370**. The binary formatted data is optimized for performance by minimizing the size. The RL consumer **342** translates the binary data from pipe **332** and translates the operations into C# instructions. In some embodiments, rendering operations **330** are generated for graphics operations and transmitted through to the native component **340** for processing and display, but audio operations are processed directly by the client component **310** (e.g., working directly with the underlying operating system of the gaming device **300** and associated device drivers, media players, or the like). Such bifurcation between audio and video processing may be beneficial in certain hardware or software architectures, such as with mobile platforms.

In some embodiments, the client component **310** establishes two paths of asynchronous communication from the client component **310** to the native component **340**, the rendering pipe **332** (e.g., for rendering operations **330**) and a path for loading operations **334**. The loading operations **334** are used to initiate loading and staging of game assets on the native component **340** in anticipation of upcoming use. In the example embodiment, the native component **340** has the various game assets for the loaded game stored in the fonts library **352**, texture library **354**, and sound library **356**. Such loading operations **334** may include various assets that are used during rendering such as, for example, a texture load operation representing a static texture or texture atlas, a font load operation including font material used for text

rendering, a video texture load operation, an image sequence load operation, an audio clip load operation, and a mask material load operation. In some embodiments, the asset manager **312** loads game assets as they are needed during game play, where in other embodiments, the asset manager **312** may load all game assets at the beginning of execution (e.g., at game initialization). When an asset is needed, the asset manager **312** generates loading operations **334** for transmission to the native component **340**, thereby resulting in assets being loaded by the asset manager **350** of the native component **340** in anticipation of upcoming use (e.g., assets referenced in upcoming rendering operations **330**). For example, any rendering operation **330** that requires loading new assets may cause loading operations **334** to be performed prior to any rendering operations **330** that reference those new assets. The rendering pipe **332**, in the example embodiment, is a FIFO pipe that provides rendering operations **330** to be performed by the native component **340** (e.g., based on the order received). Rendering operations **330** may include, for example, a 2-dimensional ("2D") sprite render operation representing a static symbol, image sequence, or video texture, a 2D text render operation representing a 2D text string from a bitmapped texture, an update mask operation to animate a mask material, a push mask operation to apply a bank of masks to the renderable items to follow, a pop mask operation to remove a bank of masks from the renderable items to follow, and a set camera operation to set camera perspective for renderable items to follow. When processing the rendering operations **330** from the rendering pipe **332**, the consumer **342** assumes a painter model, rendering objects in the order they are retrieved from the pipe **332**. In other embodiments, 3-dimensional rendering operations may be supported. Additional example intermediate rendering language operations and syntax are described in further detail below.

In one example embodiment, each frame is driven by RequestAnimationFrame (RAF) events of the WebView controlled by the JVM. For example, the WebView may include a refresh rate (e.g., in frames per second), and the RL producer **320** may generate and transmit rendering operations **330** through the rendering pipe **332** for each frame at a time, n. Rendering operations **330** may include, for example, an operation type (e.g., the sequenced operation to be executed on the native side), a node identifier (e.g., the unique identifier that ties the operation to a particular asset), and model data (e.g., game-controlled data that provides node position, size, scale, opacity, rotation, and such). Example operations may include, for example, Sprite2D, TextString2D, FrameUpdate, MaskPCommand, CameraPCommand.

Such rendering operations **330** and loading operations **334** provide hardware agnostic instructions that are generated from various source languages of the electronic game components **306** (e.g., JavaScript, Typescript, C++, C#, or the like). These hardware agnostic instructions are then processed by the native component **340**, which is configured execute such instructions on the particular local device hardware **360**. Since the client component **310** does not interact directly with the device hardware **360** or subsystems, the electronic game component **306** and client component **310** may be independent of various specific hardware and operating system differences between various platforms. Instead, the native component **340** is customized and configured to interact with the particular device hardware **360** and subsystems specific to the gaming device **300**. As such, the rendering pipeline **302** and rendering operations **330** between the producer **320** and consumer **342** allows the client component **310** and the electronic game component **306** to be hardware agnostic. Further, the client component **310** may be configured with a just-in-time compiler that facilitates JIT compilation of some or all of the electronic game component **306** independent of native limitations of the native operating system (e.g., iOS). By using web technologies to implement the game, the system described herein provides for downloadable games that do not require redeployment of the application. Rather, games and assets can be developed and deployed independently from the lobby application. By handling rendering operations directly on the native game platform (e.g., Unity), performance is significantly improved over a pure web-based rendering solution.

FIG. **3**B illustrates an example networked architecture **380** in which the gaming devices **300** may operate. In some embodiments, the gaming devices **300** may store one or more electronic games locally (e.g., assets and execution code in a local repository on internal storage). In the example embodiment shown here, the gaming devices **300** access a remote games database **374** for aspects of the electronic game (e.g., for game assets, game execution code, and the like). The games database **374** is hosted by a networked game server **372** provided on a network **370**, such as a local area network ("LAN"), wide area network ("WAN"), the Internet, or the like. In some embodiments, the games database **374** operates as a games library from which the gaming devices **300** can load games.

In some embodiments, gaming devices **300** can include mobile devices **300**A, such as smart phones or tablet computing devices of players. In some embodiments, gaming devices **300** can include personal computing devices **300**B, such as home personal computers or laptop computers of players. In some embodiments, gaming devices **300** can include EGMs **300** such as the gaming devices **104** shown in FIG. **1** and the gaming device **200** shown in FIG. **2**A. During operation, the gaming devices **300** download game components from the games database **374** for execution on the local gaming device **300**A, **300**B, **300**C as described above. In some embodiments, the gaming devices **300** may provide a graphical user interface ("GUI") that allows the player to select from a library of games provided by the games database **374** and, upon selection of a particular game for play, the gaming device **300** initiates a download of that game and associated components (e.g., assets, executables, code, or the like) and commences execution of that game locally.

Example Intermediate Rendering Language and Operations

Referring now to FIGS. **3**A and **3**B, in some embodiments, the rendering pipeline **302** uses an intermediate rendering language that includes various types of rendering operations **330** that may be transmitted across the rendering pipe **332**. For example, rendering operations **330** may include a "Sprite2D" command, which represents a command to render a 2D sprite (e.g., a static symbol, an image sequence, a video texture). The rendering operations **330** may include a "Text2D" command, which represents a command to render a 2D text string (e.g., from a bitmapped texture). The rendering operations **330** may include an "UpdateMask" command, which represents a command to animate a mask material. Some masks are static and may not change from original load parametes. The rendering operations **330** may include a "PushMask" command, which represents a command to apply a bank of masks to renderable items to follow. The rendering operations **330** may include a "PopMask" command, which represents a command to remove a bank of masks from the renderable items

to follow. The rendering operations **330** may include a "SetCamera" command, which represents a command to set camera perspective for the renderable items to follow (e.g., sent when camera has been changed).

In the example embodiment, rendering operations **330** are generated and transmitted through the rendering pipe **332** in an operations pipe format:

|# of ops=n|1: op data|2: op data| . . . |n: op data|

where n is the number of operations to follow in a given rendering operations message, and where the rendering operations message includes n subsequent operations elements. Each operations element 1 to n includes an operation, "op", and data for that operation, "data". Further, the pipeline **302** may include a vertices pipe (not separately shown) that may include vertices data for each of the 1 to n operations in a vertices pipe format:

|1: vertices data|2: vertices data| . . . |n: vertices data|

Example rendering operations **330** and their associated vertices data include:

operation: RenderCommand.Sprite2D
  Format in the ops pipe (all entries stored as 32-unsigned int)
    id: RenderCommand.Sprite2D
    hash: Texture/VideoTexture/ImageSequence hash
    vpos: Position in the ***vertices*** pipe assoicated with this command
    elementId: instance-unique id
    dirtied: boolean indicating if data is dirtied
    maskMode:mode of mask to apply to this node
    if (maskMode != Ignore)
      mask.RootId: root id of owner of mask
      mask.Bank: bank of mask
      mask.bit: bit fields of masks
      animated: boolean flag indicating if this is animatable sprite (e.g., video or imageSequence)
  Format in the vertices pipe (all entries stored as 32-Float)
    mv: modelView (16 floats for 4×4 matrix)
    width: width of sprite
    height: height of sprite
    opacity: alpha channel
    if (dirtied)
      quad-left: quad's left normalized coordinate
      quad-top: quad's top normalized coordinate
      quad-right: quad's right normalized coordinate
      quad-bottom: quad's bottom normalized coordinate
    if (animated)
      frame: frame to update before rendering.
    if (transformations)
      count: the number of transformtions
      length: the number of bytes of transformations
      transforms: the discrete transformations to allow native side to apply.
operation: RenderCommand.Text2D
  Format in the ops pipe (all entries stored as 32-unsigned int)
    id: RenderCommand.Render2DText
    vpos: Position in the ***vertices*** pipe associated with this command'
    nChars: The number of chars in the string, excluding the null character
    elementId: instance-unique id
    dirtied: boolean inidicating if data his dirited
    opacity: alpha for channel for the text
    HashTexture[ ]: an array of hash values for each character the string to be rendered.
    maskMode: mode of mask to apply to this node (see MaskMode enums)
    if (maskMode != Ignore)
      mask.RootId: root id of owner of mask
      mask.Bank: bank of mask
      mask.bit bit fields of masks
  Format in the vertices pipe (all entries stored as 32-Float)
    mv: modelView (16 floats for 4×4 matrix)
    position[ ]: an array of 2*n chars*6 representing the quad (2*3 vertices of triangles *2 coordinate * nChars) of the position on the screen that string will be rendered
    texcoord[ ]: an array of 2*nChars*6 representing uv coords in the texture for texture mapping.
    if (transformations)
      count: the number of transformtions
      length: the number of bytes of transformations
      transforms: the discrete transformations to allow native side to apply.
      width: the width of text in game pixels.
      height: the height of text in game pixels.
      scaleX: unity scale on the x-coordinate
      scaleY: unity scale on the y-coordinate.
operation: RenderCommand.UpdateMask
  Format in the ops pipe (all entries stored as 32-unsigned int)
    id: RenderCommand.UpdateMask
    rootId: hash Id for the owner of this mask. This is usually the Id of the root timeline.
    hash: hash of Mask Material
    vpos: Position in the ***vertices*** pipe assoicated with this command'

-continued

```
  Format in the vertices pipe ( all entries stored as 32-Float)
    mv:          modelView ( 16 floats for 4×4 matrix)
    vertices[ ]: an array of 3*6 representing the vertices of the mask. Vertices are
          x,y,z coords which are defined by 2 triangle, hence 6.
operation: RenderCommand.PushMask
  Format in the ops pipe ( all entries stored as 32-unsigned int)
    id:          RenderCommand.PushMask
    rootId:      hash Id for the owner of this mask. This is usually the Id of
          the root timeline.
  Format in the vertices pipe ( all entries stored as 32-Float)
    < not used >
operation: RenderCommand.PopMask
  Format in the ops pipe ( all entries stored as 32-unsigned int)
    id:          RenderCommand.PopMask
    rootId:      hash Id for the owner of this mask. This is usually the Id of the
          root timeline.
  Format in the vertices pipe ( all entries stored as 32-Float)
    < not used >
operation: RenderCommand.SetCamera
  Format in the ops pipe ( all entries stored as 32-unsigned int)
    id:          RenderCommand.SetCamera
    vpos:        Position in the ***vertices*** pipe assoicated with this command'
  Format in the vertices pipe ( all entries stored as 32-Float)
    left:        left coordinate of the viewport
    top:         top coordinate of the viewport
    right:       right coordinate of the viewport
    bottom:      bottom coordinate of the viewport
```

Additional Enhancements

In some embodiments, the rendering pipeline **302** provides incremental frame updates. To reduce the data sent across a pipe, the protocol may support an incremental frame update. In this mode, the JS code will cache the render graph on each frame. The data that will be sent across the pipe **332** will be an incremental change to the render graph from the previous frames. Consider the following:

Frame 0:

render graph-[node A: position (−10, 0)]→[node B: opacity (1.0)]→[node C: position (120, 120)]→ . . . →[node Z: position (800, 800)]

pipe data: [[node A, position(−10, 0)], [node A, opacity (1.0)], [node c, position(120, 120)], [node z, position (800, 800)]]

Frame 1:

render graph-[node A: position (−10, 0)]→[node AA: position (120, 120)]→[node B: opacity (1.0)]→ . . . →[node Z: position (800, 800)]

pipe data: [[node AA, added between (Node A and B) position(120, 120)], [node c, remove]]

The data traffic is reduced by sending the differences between the render graphs on adjacent frames.

In some embodiments, the rendering pipeline **302** implements variable frame rate rendering. Variable rate rendering allows the processes on either side of the pipe to run at different frame rates. The purpose of this mode is to promote better performance on low-end devices. The JS side of the game would be slowed down, using up less CPU on the device. The native side of the pipe would run at a desirable refresh rate. As nodes in the render tree animate, the native side would be responsible for interpolating changes to account for the game running at a slower frame rate. The frame rates would be established at system startup time.

The cost of this mode would be the loss of non-linear animations that occurred at a rate faster than the rate differential of the two processes. The animations would be emulated with a more linear path. The benefit is that the game would run smoother on a lower-end system. The option would be regulated by a customer facing application.

Consider a situation where the frame rate of the JS process is running at 15 fps, while the refresh rate of the native side is 30 fps:

Frame n (JS side)

render graph-[node A: position (−10, 100)]→ . . .]

Frame n+1 (JS side)

render graph-[node A: position (−10, 200)]→ . . .]

as compared to:

Frame m (native side)

render graph-[node A: position (−10, 100)]→ . . .]

Frame m+1 (native side)

render graph-[node A: position (−10, 150)]→ . . .]

Frame m+2 (native side)

render graph-[node A: position (−10, 200)]→ . . .]

In some embodiments, one or more of the client component **310** and the native component **340** may provide a recording component and/or a playback component (not separately shown) that facilitates recording and playback functionality for gameplay of gaming sessions. For example, in an example embodiment, the native component **340** records and stores the rendering operations **330** received from the rendering pipe **332** as an ordered "render stream." This recorded render stream may be played back by the client component **310** sending the render stream back to the native component **340** in order for processing, or the native component **340** may replay the render stream by processing the stored rendering operations **330** in order. Further, since this render stream is text based, the render stream may be compressed with a high degree using known compression techniques, allowing low bandwidth, lossless quality recording of game play with minimal processing overhead. Such recording, for example, may provide customer support with an exact playback of what the user experienced in any customer dispute situation.

Methods for Providing the Rendering Pipeline

FIG. **4** is a swimlane diagram of an example method **400** for providing a rendering pipeline for an electronic game, such as the rendering pipeline **302** shown in FIG. **3**A. In some embodiments, the method **400** may be performed by any of the various gaming devices **300** shown in FIGS. **3**A and **3**B. In the example embodiment, the method **400**

includes initiating the electronic game at operation **410**. At operation **412**, the native component **340** creates a JVM with a WebView in the client component **310**, culminating in the creation of the client component **310** at operation **414**. At operation **420**, the native component **340** downloads game source code, assets, and configuration settings (e.g., from games database **374**, from local memory, or the like). At operation **422**, the native component accesses device dimensions for the local device (e.g., screen size, max refresh rate, or the like, for the gaming device **300**).

In the example embodiment, at operation **430**, the native component **340** injects handlers into the game source code. The handlers add code for the render language producer **320**, which allows the game to establish the rendering pipe **332**, construct rendering operations **330**, and the other various client-side operations described herein. In one example embodiment, a single JS-DOM element is injected into the JavaScript, varying slightly based upon the operating system and environment present on the gaming device **300** (e.g., iOS with WebKit, Android with Chromium, or the like). For example:

```
window.Unity={
call: function(msg){
  window.webkit.messageHandlers.unityControl-
    .postMessage(msg);
}
{
```

This allows the JavaScript engine to determine whether the RL consumer **342** is listening and switch all presentation calls to instead be serialized through the window.Unity.call (string) DOM function.

At operation **432**, the client component **310** downloads the "enhanced" source code from the native component **340** and, at operation **434**, performs game initialization, including a just-in-time compilation and execution of the game source code. At operation **436**, the client component **310** establishes the rendering pipe **332** and heartbeat **336** with the native component **340** (e.g., via execution of the handlers injected into the source code at operation **430**). At operation **438**, the native component **340** connects with the client component **310** and prepares the render language consumer **342** for rendering processing. At operation **440**, execution of the electronic game begins generating graphics operations (e.g., source output operations), which causes the render language producer **320** to translate those source output operations into rendering operations **330** in the intermediate rendering language described herein and transmit those rendering operations **330** to the native component **340** via the rendering pipe **332**. At operation **442**, the rendering operations **330** are received by the native component **340** (e.g., by the render language consumer **342**), which converts the intermediate render language operations into local hardware operations (e.g., audio, video), causing display of the game assets as indicated by the rendering operations **330**. In the example embodiment, the rendering pipeline **332** is an asynchronous data flow from the client component **310** to the native component **340** in which the messages need not be acknowledged or necessarily processed before the next commands are sent. In some embodiments, the native component **340** sends a heartbeat **336** at operation **450** on a periodic frequency and the client component **310** may transmit rendering commands **330** based on the heartbeat **336**.

Various Technical Advantages

The various embodiments of the rendering pipeline **302** for gaming devices **300** described herein provide any or all of the following technical advantages over the prior art: (A) performance on mobiles may be increased due to always using an engine with the capacity to JIT the javascript code; (B) objects are created in world space which is native to that of the main application (e.g., the Heart of Vegas application which is a native Unity3d application will have more flexibility on where the content is rendered on screen, having a new ability to richly define the layering (lobby objects can live behind, in front of, at the same level as all or some of the game elements), which may not be possible when the game is rendered to an opaque GL surface as in previous implementations; (C) the actual rendering API is not tied to the intermediate rendering language, allowing the rendering pipeline **302** to switch to using a newer native rendering API when older ones get deprecated (e.g., Apple may decide to remove OpenGLES 2 support in an upcoming iOS revision), where previous implementations would rewrite the game to support a transition to another backend API, where this implementation provides native support for whatever the client application supports; (D) the game lobby has richer control over the textures used by the game, allowing the lobby to, for example, replace assets baked into the slot game with newer ones for a Christmas event, where, previously, modification of game assets post export was difficult; (E) QA have a new avenue in which they can run automated tests, where, for example, these automated tests can be written in C# and live inside the Unity application, and they can work via walking over the Unity3d scene graph to determine states of components, and where there is no requirement to instrument or modify the underlying slot game to make this possible; (F) the rendering application is abstracted away from the game render server, where, for example, it would be trivial to move to a new engine (Unreal, for example)—this would not require changes to the game or the bespoke rendering language; (G) reduce power (e.g., battery) consumption on gaming devices (e.g., mobile devices) through streamlined processing and reduced complexity.

A computer, controller, or server, such as those described herein, includes at least one processor or processing unit and a system memory. The computer, controller, or server typically has at least some form of computer readable non-transitory media. As used herein, the terms "processor" and "computer" and related terms, e.g., "processing device", "computing device", and "controller" are not limited to just those integrated circuits referred to in the art as a computer, but broadly refers to a microcontroller, a microcomputer, a programmable logic controller (PLC), an application specific integrated circuit, and other programmable circuits "configured to" carry out programmable instructions, and these terms are used interchangeably herein. In the embodiments described herein, memory may include, but is not limited to, a computer-readable medium or computer storage media, volatile and nonvolatile media, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules, or other data. Such memory includes a random access memory (RAM), computer storage media, communication media, and a computer-readable non-volatile medium, such as flash memory. Alternatively, a floppy disk, a compact disc-read only memory (CD-ROM), a magneto-optical disk (MOD), and/or a digital versatile disc (DVD) may also be used. Also, in the embodiments described herein, additional input channels may be, but are not limited to, computer peripherals associated with an operator interface such as a mouse and a keyboard. Alternatively, other computer peripherals may also be used that may include, for example, but not be

limited to, a scanner. Furthermore, in the exemplary embodiment, additional output channels may include, but not be limited to, an operator interface monitor.

As indicated above, the process may be embodied in computer software. The computer software could be supplied in a number of ways, for example on a tangible, non-transitory, computer readable storage medium, such as on any nonvolatile memory device (e.g. an EEPROM). Further, different parts of the computer software can be executed by different devices, such as, for example, in a client-server relationship. Persons skilled in the art will appreciate that computer software provides a series of instructions executable by the processor.

While the invention has been described with respect to the figures, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit of the invention. Any variation and derivation from the above description and figures are included in the scope of the present invention as defined by the claims.

What is claimed is:

1. An electronic gaming device providing a rendering pipeline for an electronic game, the electronic gaming device comprising:

a memory device storing the electronic game, a client component of the rendering pipeline, and a native component of the rendering pipeline;

a display device upon which video output of the electronic game is rendered; and

at least one processor configured to execute the client component and the native component,

the client component, when executed on the at least one processor, is configured to:

initiate a rendering operations pipe between the client component and the native component;

convert display commands from a source language of the electronic game into rendering operations of an intermediate rendering language; and

transmit the rendering operations through the rendering operations pipe to the native component;

the native component, when executed on the at least one processor, is configured to:

receive the rendering operations via the rendering operations pipe;

translate the rendering operations from the intermediate rendering language into rendering operations of the native component; and

perform the rendering operations of the native component on the display device.

2. The electronic gaming device of claim **1**, wherein the client component includes a virtual machine that is configured to perform just-in-time compilation and execution of the electronic game.

3. The electronic gaming device of claim **1**, wherein the source language of the electronic game is one of JavaScript and Typescript, wherein the client component includes a java virtual machine that executes the electronic game.

4. The electronic gaming device of claim **3**, wherein the client component is configured to create a WebView object and execute source code of the electronic game via offscreen WebKit rendering in the WebView object.

5. The electronic gaming device of claim **1**, wherein the client component is configured to transmit asset loading operations to the native component, wherein the native component is configured to load assets identified by the asset loading operations.

6. The electronic gaming device of claim **1**, wherein at least some of the rendering operations of the intermediate rendering language include an operation type, a node identifier, and model data.

7. The electronic gaming device of claim **1**, wherein a heartbeat is established between the native component and the client component, wherein the client component uses the heartbeat as timing for when to generate and transmit rendering operations through the rendering operations pipe.

8. A method for providing a rendering pipeline for an electronic game on an electronic gaming device, the electronic gaming device including a memory device storing the electronic game, a client component of the rendering pipeline, and a native component of the rendering pipeline, the electronic gaming device also including a display device upon which video output of the electronic game is rendered and at least one processor configured to execute the client component and the native component, the method comprising:

establishing a rendering operations pipe between the client component and the native component;

converting, at the client component, display commands from a source language of the electronic game into rendering operations of an intermediate rendering language;

transmitting the rendering operations through the rendering operations pipe from the client component to the native component;

receiving, at the native component, the rendering operations via the rendering operations pipe;

translating the rendering operations from the intermediate rendering language into rendering operations of the native component; and

performing the rendering operations of the native component on the display device.

9. The method of claim **8**, wherein the client component includes a virtual machine that is configured to perform just-in-time compilation and execution of the electronic game.

10. The method of claim **8**, wherein the source language of the electronic game is one of JavaScript and Typescript, wherein the client component includes a java virtual machine that executes the electronic game.

11. The method of claim **10**, wherein the client component is configured to create a WebView object and execute source code of the electronic game via offscreen WebKit rendering in the WebView object.

12. The method of claim **8**, wherein the client component is configured to transmit asset loading operations to the native component, wherein the native component is configured to load assets identified by the asset loading operations.

13. The method of claim **8**, wherein at least some of the rendering operations of the intermediate rendering language include an operation type, a node identifier, and model data.

14. The method of claim **8**, wherein a heartbeat is established between the native component and the client component, wherein the client component uses the heartbeat as timing for when to generate and transmit rendering operations through the rendering operations pipe.

15. A non-transitory computer-readable medium storing instructions that, when executed by a processor of an electronic gaming device, cause the processor to:

establish a rendering operations pipe between a client component and a native component;

convert, at the client component, display commands from a source language of an electronic game into rendering operations of an intermediate rendering language;

transmit the rendering operations through the rendering operations pipe from the client component to the native component;

receive, at the native component, the rendering operations via the rendering operations pipe;

translate the rendering operations from the intermediate rendering language into rendering operations of the native component; and

perform the rendering operations of the native component on a display device.

16. The non-transitory computer-readable medium of claim **15**, wherein the client component includes a virtual machine that is configured to perform just-in-time compilation and execution of the electronic game.

17. The non-transitory computer-readable medium of claim **15**, wherein the source language of the electronic game is one of JavaScript and Typescript, wherein the client component includes a java virtual machine that executes the electronic game, wherein the client component is configured to create a WebView object and execute source code of the electronic game via offscreen WebKit rendering in the WebView object.

18. The non-transitory computer-readable medium of claim **15**, wherein the client component is configured to transmit asset loading operations to the native component, wherein the native component is configured to load assets identified by the asset loading operations.

19. The non-transitory computer-readable medium of claim **15**, wherein at least some of the rendering operations of the intermediate rendering language include an operation type, a node identifier, and model data.

20. The non-transitory computer-readable medium of claim **15**, wherein a heartbeat is established between the native component and the client component, wherein the client component uses the heartbeat as timing for when to generate and transmit rendering operations through the rendering operations pipe.

* * * * *